

Strategic Environmental Research and Development Program

Proceedings of the 2nd Annual Site Characterization and Analysis Penetrometer System (SCAPS) Sensor Development Workshop

29-30 August 1995, Vicksburg, Mississippi

by Ernesto R. Cespedes, Diane M. Cargile

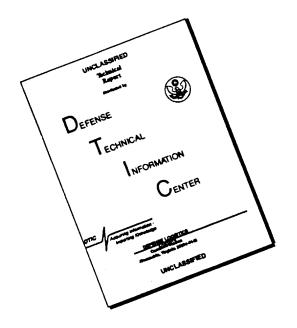
DTIC QUALITY INSPECTED 4

Approved For Public Release; Distribution Is Unlimited

19961008 047

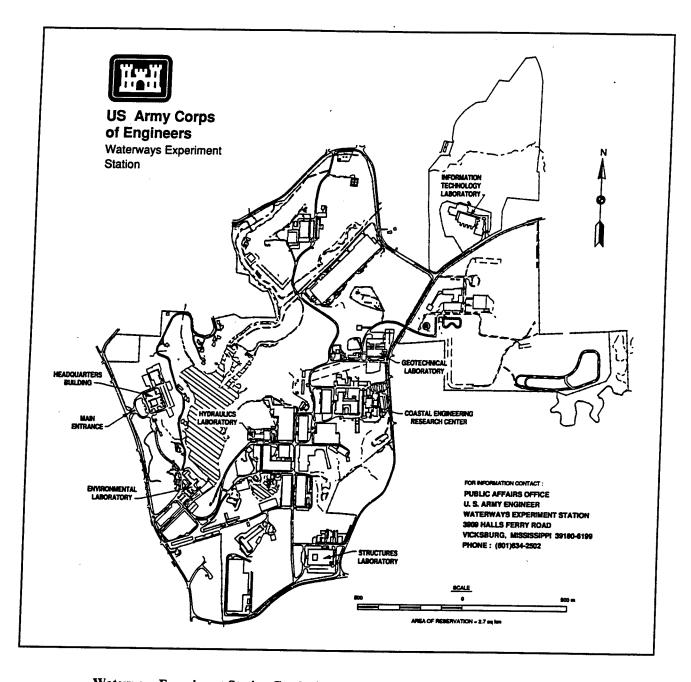


DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.



Waterways Experiment Station Cataloging-in-Publication Data

Site Characterization and Analysis Penetrometer System Sensor Development Workshop (2nd: 1995: Vicksburg, Mississippi)

Proceedings of the 2nd Annual Site Characterization and Analysis Penetrometer System (SCAPS) Sensor Development Workshop, 29-30 August 1995, Vicksburg, Mississippi / by Ernesto R. Cespedes, Diane M. Cargile; prepared for U.S. Army Corps of Engineers.

314 p.: ill.; 28 cm. - (Miscellaneous paper; SERDP-96-2)

Includes bibliographic references.

1. Penetrometer -- Congresses. 2. Contamination (Technology) -- Congresses. 3. Environmental Engineering -- Congresses. 4. Pollution -- Environmental aspects -- Congresses. I. Cespedes, Ernesto R. II. Cargile, Diane M. III. United States. Army. Corps of Engineers. IV. U.S. Army Engineer Waterways Experiment Station. V. Strategic Environmental Research and Development Program (U.S.) VI. Title. VII. Title. 2nd Annual Site Characterization and Analysis Penetrometer System (SCAPS) Sensor Development Workshop. VIII. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station); SERDP-96-2.

TA7 W34m no.SERDP-96-2

Contents

Preface iv
1—Introduction
Background
2—SERDP Peer Review Panel
3—Attendees
4—Agenda 8
5—Abstracts, Papers, and/or Presentation Materials
6—SERDP Peer Review Panel Conclusions and Recommendations 217
7—User Needs
8—DOE Related Research
9—SERDP Peer Review Panel Conclusions and Recommendations 289
References
SF 298

Preface

The 2nd Annual Site Characterization and Analysis Penetrometer System (SCAPS) Sensor Development Workshop was held at the U.S. Army Engineer Waterways Experiment Station (WES) on 29-30 August 1995. The workshop was sponsored by the Strategic Environmental Research and Development Program (SERDP), Washington, DC, under Project Number 94-729, "Accelerated Tri-Services SCAPS Sensor Development." Dr. John Harrison is Acting Executive Director, SERDP.

The workshop was organized and coordinated by Dr. Ernesto R. Cespedes, Environmental Engineering Division (EED), Environmental Laboratory (EL), WES, with the assistance of Ms. Diane M. Cargile, EED. This report on the proceedings of the workshop was compiled and prepared by Dr. Cespedes and Ms. Cargile.

This report was prepared under the general supervision of Mr. Norman R. Francingues, Chief, EED, and Dr. John W. Keeley, Director, EL.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Bruce K. Howard, EN, was Commander.

This report should be cited as follows:

Cespedes, E. R., and Cargile, D. M. (1996). "Proceedings of the 2nd annual Site Characterization and Analysis Penetrometer System (SCAPS) sensor development workshop, 29-30 August 1995," Miscellaneous Paper SERDP-96-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

1 Introduction

Background

The Site Characterization and Analysis Penetrometer System (SCAPS) is receiving wide acceptance as a versatile tool for rapid subsurface screening of contaminated sites. Since the fielding of the first SCAPS vehicle at the U.S. Army Engineers Waterways Experiment Station (WES) during 1990, the Tri-Service SCAPS fleet has grown to seven vehicles (four Army and three Navy). In addition, the Department of Energy operates two SCAPS vehicles, and private contractors, under licensing agreements, operate a number of SCAPS technologies that support DoD, DOE, and EPA site characterization efforts.

The SCAPS platform consists of a 20-ton truck equipped with vertical hydraulic rams capable of pushing a cone penetrometer into the ground at a speed of 2 cm/sec to depths of over 50 m in nominally consolidated, fine-grained soils. During a push, SCAPS is capable of collecting subsurface stratigraphy data with spatial resolutions of 2 cm, as well as chemical contaminant data by means of sensors and samplers incorporated into the penetrometer head. The primary application of SCAPS technology has been to characterize sites contaminated with heavy petroleum, oils, and lubricants (POLs) by means of a laser induced fluorescence (LIF) sensors (Lieberman et al. 1991). Successful fielding of the LIF technology led to increased interest in expanding SCAPS capabilities to address other contaminants (Cespedes et al. 1994)

In 1994 the Strategic Environmental Research and Development Program (SERDP) funded a Tri-Service effort to accelerate the development and testing of advanced sensors and sampling technologies for SCAPS to allow characterization of sites containing explosives, metals, volatile organic compounds (VOCs), light POLs, and radioactive wastes (SERDP 1995). During the 1994 SERDP Program Review, the Scientific Advisory Board requested that a peer review panel be set up to monitor the progress of the sensor development project. It was also requested that yearly meetings be held that included the peer review panel, the Tri-Service developers, and the SCAPS users. The first meeting was held during 16-17 August 1994 and was expanded to include DOE and EPA researchers and users. This report describes the second

meeting which was held during 29-30 August 1995 at the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Objective

The primary objective of this workshop was to have the Peer Review Panel evaluate the progress of the SCAPS sensor development project during the previous year and to have them recommend changes or re-directions of the research effort. In addition, the workshop provided an open forum for discussion of ongoing sensor development activities related to SCAPS within the Tri-Service, DOE, and EPA, with the goal of fostering partnering between agencies and reducing any duplication of effort. Lastly, the workshop provided an opportunity for SCAPS managers and users to evaluate ongoing research and to provide feedback to the sensor developers.

2 SERDP Peer Review Panel

Mr. Eric Lightner

U.S. Department of Energy EM-541 1999901 Germantown Road Germantown, Maryland 20874

Dr. Greg Rosasco

Chief, Process Measurement Division National Institute of Standards and Technology Chemical Science and Technology Laboratory Gaithersburg, Maryland 20899

Dr. Carl Enfield

Robert S. Kerr Environmental Research Laboratory U.S. Environmental Protection Agency 919 Kerr Research Drive Ada, Oklahoma 74820

Dr. Jim Marqusee

Office of Deputy Under Secretary of Defense for Environmental Security (ODUSD (ES)) 3000 Defense Plaza Washington, DC 20301-3000

3 Attendees

Dr. Jane Adams

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3906

FAX: 601-634-2732

Dr. Ishwar Aggarwal

Naval Research Laboratory CODE 5603 Washington, DC 20375-5338 Phone: 202-767-93190r9316

FAX: 202-767-5792

Dr. Femi Ayorinde

SERDP Program Office 901 North Stuart Street Suite 304 Arlington, VA 22203 Phone: (703) 696-2118 FAX: (703) 696-2114

Mr. John Ballard

USAE Waterways Experiment Station CEWES-EP-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199

Phone: 601-634-2446 FAX: 601-634-2732

Dr. Pam Boss

NRaD
Naval Command, Control and Ocean
Surveillance Center (NCCOSC)
RDT&E Division, Code 521
53605 Hull Street
San Diego, CA 92152-5410
Phone: (619) 553-1608

FAX: (619) 553-1269

Dr. James Brannon

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3906

FAX: 601-634-2732

Dr. Ernesto Cespedes

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3906 FAX: 601-634-2732

Mr. Javier Cortes

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3538 FAX: 601-634-2732

Dr. William Davis

USAE Waterways Experiment Station CEWES-ES-P 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3786 FAX: 601-634-3120

Dr. Paul Doskey

Argonne National Laboratory Environmental Research Division 9700 S Cass Avenue Argonne, IL 60439 Phone: 708-252-7662 Fax: 708-252-5498

Mr. Arbor Drinkwine

US Army Engineer District, Kansas City, CEMRK-700 Federal Building Kansas City, MO 64106-2896

Phone: (816) 426-3794 FAX: (816) 426-5462

Dr. Tim Elam

Naval Research Laboratory Code 6685 4555 Overlook Avenue, SW Washington, DC 20375-5345

Dr. Carl Enfield

U.S. Environmental Protection Agency P.O. Box 1198 Ada, OK 74820

Phone: (405) 436-8530 FAX: (405) 436-8582

Mr. Dan Eng

USAE Waterways Experiment Station CEWES-IM-JD 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3409

FAX: 601-634-3409

Mr. Joel Everett

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3683

FAX: 601-634-2732

Mr. Norman Francingues

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3703 FAX: 601-634-4263

Mr. Ricky Goodson

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601 634 2460

Phone: 601-634-2469 FAX: 601-634-2732

Mr. George Hall

U.S. Army Engineer, Tulsa District CESWT-EC-GG P. O. Box 61 Tulsa, OK 74121-0061 918-669-7169

Fax: 918-669-7532

Mr. Erik Hangeland

U.S. Army Environmental Center SFIM-AEC-ETD Bldg. E4430 Aberdeen Proving Ground, MD 21010 Phone: (410) 612-6858

FAX: (410) 612-6836

Dr. John Keeley

USAE Waterways Experiment Station CEWES-EV-Z 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3477 FAX: 601-634-3842

Dr. Bob Knowlton

SNL/DOE Sandia National Laboratories MS 1348 Albuquerque, NM 87185-1348 Phone: 505-848-0425

FAX: 505-848-0417

Mr. Karl Konecny

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3972 FAX: 601-634-3833

Mr. Steve Larson

USAE Waterways Experiment Station CEWES-EE-C 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3431 FAX: 601-634-2742

Mr. Dan Leavell

USAE Waterways Experiment Station CEWES-GS-GC 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-2496

FAX: 601-634-4219

Mr. Bob Lien

U.S. Environmental Protection Agency P O Box 1198 Ada, OK 74820 Phone: 405-332-8555

Fax: 405-332-8703

Dr. Stephen Lieberman

Naval Command, Control and Ocean Surveillance Center RDT&E Division, Code 521 271 Catalina Blvd. San Diego, CA 92152-5000 Phone: 619-553-2778

Phone: 619-553-2778 FAX: 619-553-6305

Mr. Eric Lightner

U.S. Department of Energy DOE-EM-531 19901 Germantown Road Germantown, MD 20874 Phone: (301) 903-7935

Fax: (301) 903-7457

Dr. Jeff Marqusee

Office of Deputy Under Secretary of Defense for Environmental Security (ODUSD (ES)) 3000 Defense Plaza Washington, DC 20301-3000 Phone: (703) 614-3090

FAX: (703) 614-3090

Mr. Randy Mead

U.S. Army Engineer, Tulsa District CESWT-EC-GS P O Box 61 Tulsa, OK 74121-0061

Phone: 918-669-7019 FAX: 918-669-7526

Mr. Cliff Morgan

USAE Waterways Experiment Station CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-2108 FAX: 601-634-2732

Mr. Bruce Nielsen

US Air Force Armstrong Laboratories AL/EQW-OL BLDG 1117 139 Barnes Drive Tyndall AFB, FL 32403-5323 Phone: 904-283-6011

Phone: 904-283-6011 FAX: 904-283-6090

Mr. Jeff Powell

USAE Waterways Experiment Station CEWES-IM-JD 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-3407 FAX: 601-634-2747

Mr. Bobby Reed

USAE Waterways Experiment Station CEWES-IM-JD 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-2575 FAX: 601-634-2747

Mr. Bryan Register

USAE Waterways Experiment Station CEWES-IM-JD 3909 Halls Ferry Road Vicksburg, MS 39180-6199 Phone: 601-634-2748 FAX: 601-634-2747

Dr. Greg Rosasco

Chemical Science and Technology Laboratory National Institute of Standards and Technology (NIST) Gaithersburg, MD 20899 Phone: (301) 975-2600 FAX: (301) 869-5924

Dr. Ross Sausa

U.S. Army Research Laboratory AMSRL-WT-PC Aberdeen Proving Ground, MD 21005

Ms. Ann Strong

USAE Waterways Experiment Station CEWES-EE-C 3909 Halls Ferry Road Vicksburg, MS 39182-6199 Phone: 601-634-2726

FAX: 601-634-2742

Mr. Greg Theriault

NRaD

Naval Command, Control and Ocean Surveillance Center (NCCOSC) RDT&E Division, Code 521 53605 Hull Street San Diego, CA 92152-5410 Phone: (619) 553-1608

FAX: (619) 553-2876

Mr. Gordon Wood

SERDP Program Office 901 North Stuart Street Suite 304 Arlington, VA 22203

Phone: (703) 696-2120 FAX: (703) 696-2114

4 Agenda

SCAPS Sensor Development Workshop 29-30 August 1995 USAE Waterways Experiment Station 3909 Halls Ferry Road Vicksburg, Mississippi

Tuesday, 29 August 1995

0830	Welcome COL Howard (WES Commander)				
0835	Overview Dr. Keeley (Env. Lab Director)				
0845	Introduction of SERDP Panel Membership Dr. Cespedes (WES)				
0900	Project Description/Status Dr. Cespedes				
0915	SERDP Program Research Areas Dr. Cespedes				
	I. Laser Induced Breakdown Spectroscopy(LIBS) Dr. Cespedes Dr. Miziolek (ARL) Mr. Theriault (NRaD)				
	II. Laser Induced Fluorescence Sensors				
	A. POL				
1045	Break				
1100	III. Fiber Optic Raman Sensors Dr. Boss (NRaD) Mr. Nielsen				

IV. Electrochemical Sensors A. Explosives Dr. Cespedes B. VOC Dr. Davis (WES) V. Spectral Gamma Probe Mr. Register (WES) 1230 Lunch VI. Sampling Technology Dr. Brannon (WES) 1315 Dr. Davis Mr. Leavell (WES) VII. Data Processing Methodologies Mr. Goodson (WES) VIII. Technology Demonstration/Implementation Dr. Davis Mr. Drinkwine (MRK, COE) Dr. Lieberman 1500 **Break** User Needs SCAPS Managers & Operators 1515 (ARMY, Navy, DOE, EPA) 1630 Adjourn Wednesday, 30 August 1995 0830 Conclusions and Recommendations SERDP Panel 0915 DOE/EPA/DoD Related Research A. On-Line Organic Sampler Dr. Doskey (ANL) B. Moisture and Pore Pressure Sensors Dr. Knowlton (SNL) C. Fiber Optic IR Sensor Dr. Aggarwal (NRL) 1000 Break 1015 DOE/EPA/DoD Related Research (Continued) D. X-Ray Fluorescence Sensor Dr. Elam (NRL) E. New Coring Device Mr. Lien (EPA) F. Field Portable LIBS Dr. Cremers (LANL) G. Direct Sparge Sampler Dr. Davis H. Optical Sensors Dr. Vo-Dinh (ORNL) DOE/DoD Coordination and Collaboration All 1130

Chapter 4 Agenda 9

1200	Lunch
1300	Tour of SCAPS Truck Mr. Konecny (WES) 3-D Visualization Demonstration Mr. Goodson ITMS Demonstration Dr. Davis
1430	Adjourn

5 Abstracts, Papers and/or Presentation Materials

The following three chapters contain briefing materials submitted by the workshop presenters and are printed as submitted with no editing. Although varied in format, the materials in this section represent a good summary of the workshop. In addition to the presentations and discussions described in this report, the workshop included demonstrations of SCAPS prototype probes and samplers, of the SCAPS 3-D visualization software, and of the modified hydraulic equipment in the WES SCAPS truck.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	Ву	To Obtain
cubic feet	0.2831685	cubic meters
Fahrenheit degrees	5/9	Celsius degrees or kelvins ¹
feet	0.3048	meters
inches	0.0254	meters
pound (force) inches	0.1129848	newton meters
miles (U.S. statute)	1.609347	kilometers
pounds (force) per square foot	47.88026	pascals
pounds (mass)	0.4535924	kilometers

 $^{^1}$ To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use this following formula: C=(5/9) (F-32). To obtain kelvin (K) readings, use: K=(5/9) (F-32) + 273.15.



PROJECT DESCRIPTION



 SCAPS project is a fully coordinated Tri-Services effort to significantly accelerate the development, testing, and demonstration of sensor and sampler technologies to enhance the capabilities of SCAPS to detect and map subsurface contaminants in situ

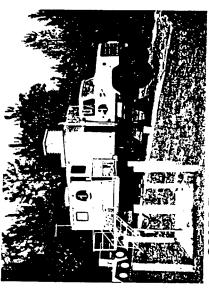


TECHNICAL OBJECTIVES



- Accelerate the development, testing, and demonstration of the following SCAPS technologies:
 - I LIBS metals
 - II LIF POLs, explosives
 - III FORS VOCs
 - IV Electrochemical sensors VOCs, explosives
 - V Spectral Gamma Probe radioactive wastes
 - VI Sampling
 - VII Data processing

SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM (SCAPS)



SCAPS Truck and Grout Trailer (Monitoring Well in Foreground)



Cone Penetrometer With Sensor Package

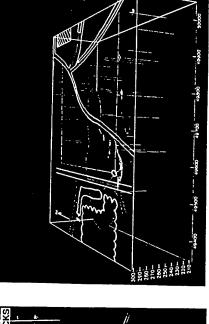


Hydraulic Operations Compartment

Data Acquisition/Processing Compartment



Grout Trailer



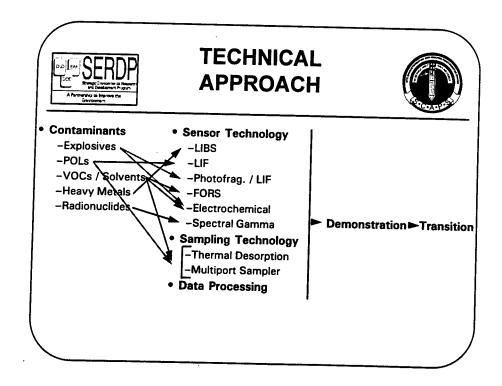
Three-Dimensional Contaminant Visualization



TECHNICAL APPROACH



- Select candidate sensing technologies
 - Appropriate for DoD, DOE, EPA contaminants of interest
 - Potential for rapid, in situ applications
 - Implementable in SCAPS
- Develop laboratory instrumentation to evaluate technology
 - -Soil matrix effects
- SCAPS implementation considerations
- -Detection limits
- Develop associated support technologies
 - -Data acquisition hardware / software Scientific visualization
 - -Data analysis
- Develop prototype SCAPS sensor probe
- · Conduct laboratory / field tests
- Conduct demonstration of new SCAPS sensor systems





TECHNICAL APPROACH



• Exploit technological advances

- -Fiber optics
- -Solid state tunable lasers
- Diode lasers / arrays
- Detector technologies
- Computer hardware
- Developments in the field or laser applications to chemical analysis



TECHNICAL RISKS



- Transition of laboratory methods to operational (field use) technology
- Performance variability of in situ sensors with site-specific conditions
 - Soil matrix
 - Interferences
 - Contaminant mix
 - Contaminant state



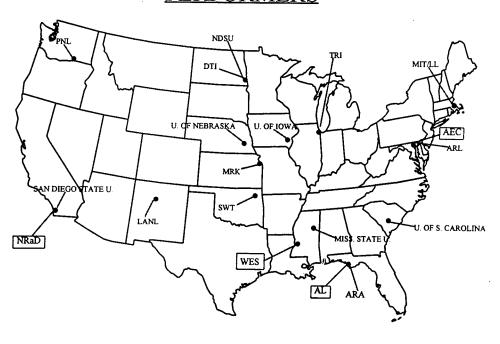
PERFORMERS



- · Lead Lab U.S. Army Engineer Waterways Experiment Station
- Technical POC E. Cespedes
- · Co-Principal Investigators
 - U.S. Army Environmental Center, Aberdeen Proving Ground, MD
 - Naval Command, Control and Ocean Surveillance Center, RDT&E Division (NRaD), San Diego, CA
 - Armstrong Laboratory, Environics Directorate, Tyndall AFB, FL
- Other Performers
 - U.S. Army Research Laboratory
 - North Dakota State University
 - University of South Carolina
 - University of Nebraska-Lincoln
 - Mississippi State University
 - University of Iowa

- MIT/LL
- Transducer Research, Inc.
- Los Alamos National Laboratory
- Naval Research Laboratory
- Others TBD

PERFORMERS





HIGHLIGHTS



- New prototype SCAPS probes
 - Explosives
 - Thermal desorption VOC sampler
 - Electrochemical VOC probe
 - FORS probe
- Demonstrated 3-D visualization in field
- Successful LIF demonstrations involving EPA, WGA

FIELD TESTS / DEMONSTRATIONS





PAST PERFORMANCE



	FY93	<u>FY94</u>	FY95
Technical Papers	3	2	>15
Conference / Symposium Presentations	7	9	>20
Technical Reports	1	1	2
Patent Disclosures / Applications	1	2	1
CRADAs	0	1	1
Licensing Agreements	0	2	0



RESEARCH AREA I LIBS SENSOR



2	Milestones	Schd	Reschd	Comp
•	Complete characterization of optical fiber	06/94	09/94	09/94
•	Complete laboratory prototype F.O. LIBS system	09/94	10/94	10/94
•	Complete design of prototype LIBS probe	96/60		
•	Complete LIBS software development	11/95		
•	Complete fabrication of LIBS prototype probe	96/20		
•	Complete field tests / demonstration of LIBS system	12/96		

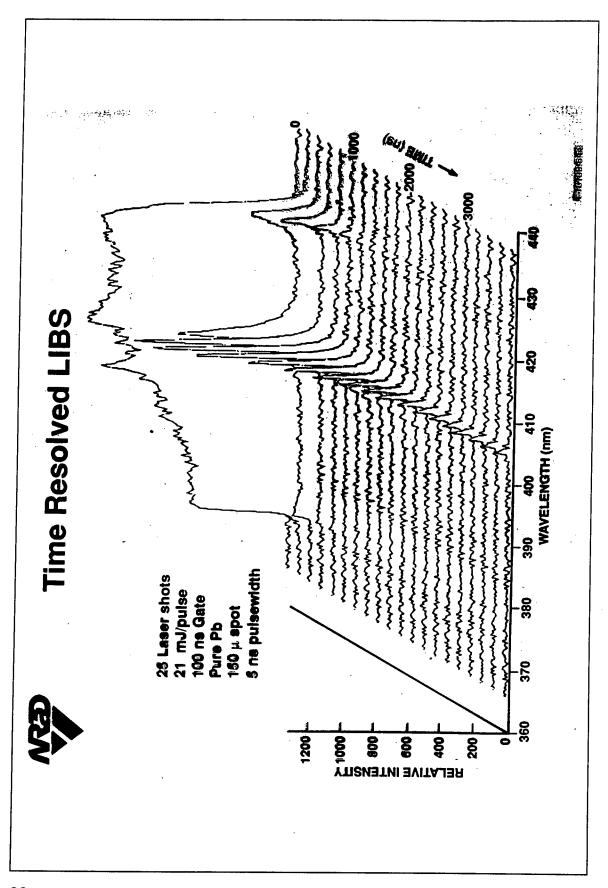


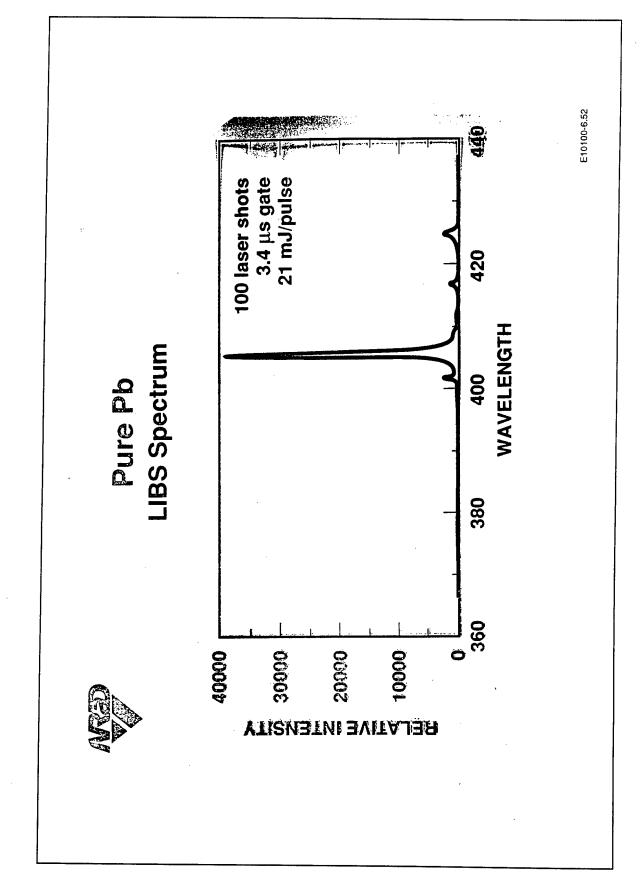
LIBS R&D TASKS

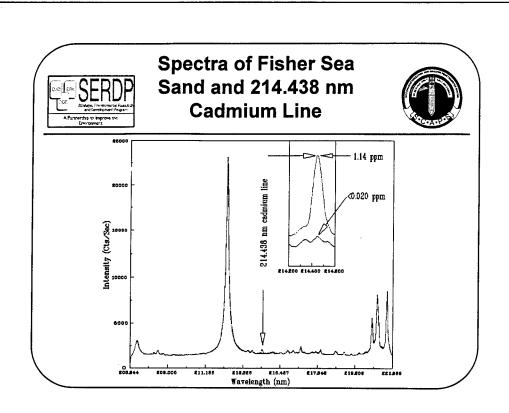


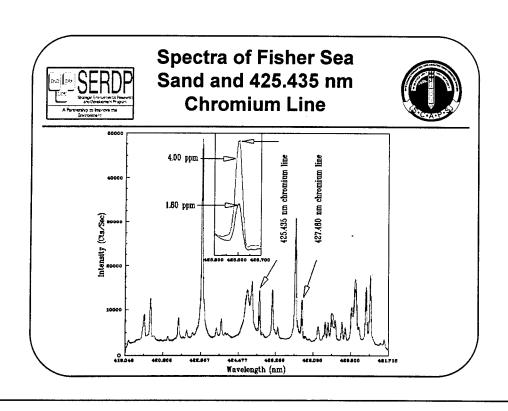
- Evaluate approaches for in situ plasma generation
 - WES
- NRaD
- LANL
- UNL
- Design & characterize fiber optic delivery system
 - NRaD
- Evaluate alternate detection methods
 - ARL
- Develop software techniques for automatic multi-element detection/quantification
 - WES
 - NRaD
 - LANL

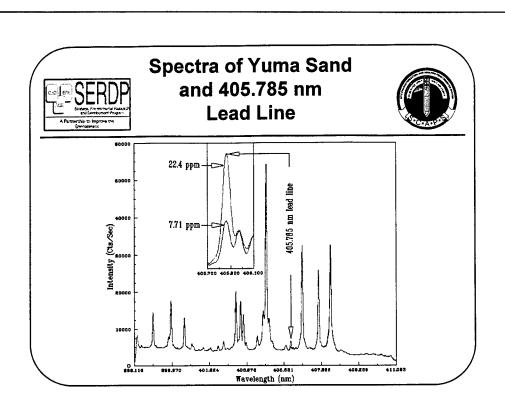
SCHEMATIC OF LIBS DIAGNOSTIC SYSTEM , ICCD **GATE** CONTROLLER **PULSER** COMPUTER SPECTRO-**ICCD ND:YAG LASER METER** FIBER-OPTICS

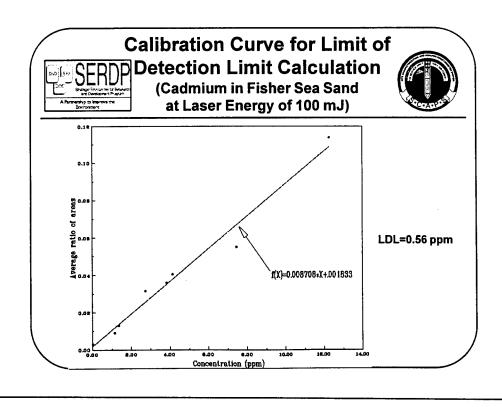








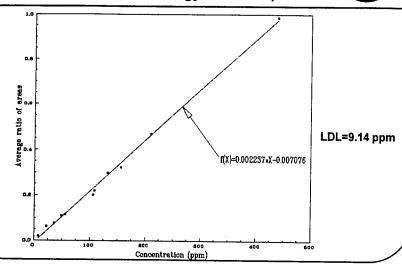




Calibration Curve for Limit of Detection Calculation

(Lead in Yuma Sand at Laser Energy of 100 mJ)







LIBS Results Summary



				EPA Actic	EPA Action Levels	
Heavy <u>Metal</u>	Spectral <u>Line nm</u>	Background Concentration ppm	LIBS Lower Detection Limit ppm	Water ppm	Soil ppm	
Pb.	405.783	7.71	9.14	5.0	400.0*	
Pb	405.783	1.53	3.32	5.0	400.0*	
Cr	425.435	1.80	1.62	5.0	400.0**	
Cd	214.438	<0.02	0.56	1.0	40.0	
Hg	435.835	0.30	3.77	2.0	20.0	
Zn	202.548	1.30	0.99	N/A	N/A	

Kentucky - Action level > background in soil (minimum 20 ppm)

Michigan - Action level 420 ppm in soil

Pennsylvania - Action level 200 ppm residential soil, and 600 ppm industrial soil

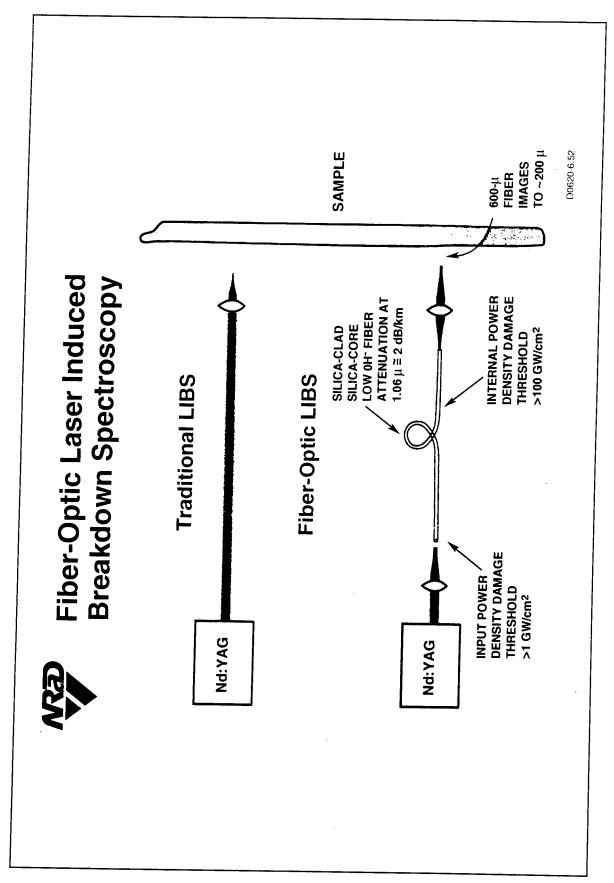
North Dakota - Action level 5 ppm in soil North Dakota - Action level 5 ppm in soil



Remote in situ detection of heavy metal contamination in soils using a fiber spectroscopy (FOLIBS) system optic laser induced breakdown

Gregory A. Theriault Stephen H. Lieberman

Naval Command, Control and Ocean Surveillance Center San Diego, CA





Desirable Features in a CPT Contaminant Probe

- Specific Allows for Identification of Contaminant of Interest
- Simple Requires Minimal Sample Preparation with only Optical Interrogation
- Rapid Allows Site Characterization Decisions to be Made in Real Time
- Remote Measurement to be Done Over Optical Fibers
- Inexpensive Probe

C N

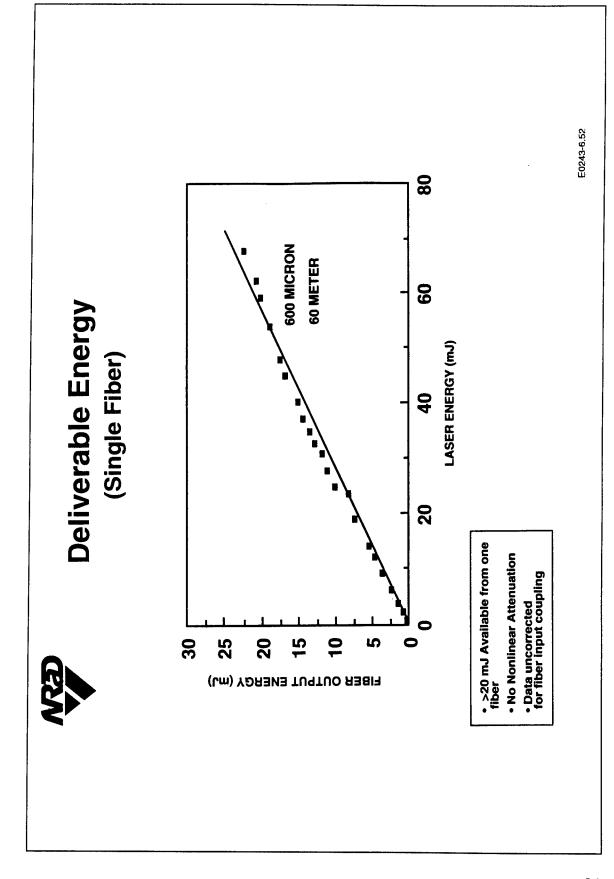
Spark Initiation Threshold on Soil 0.75mJ, 9 ns Pulse, 150μ Spot

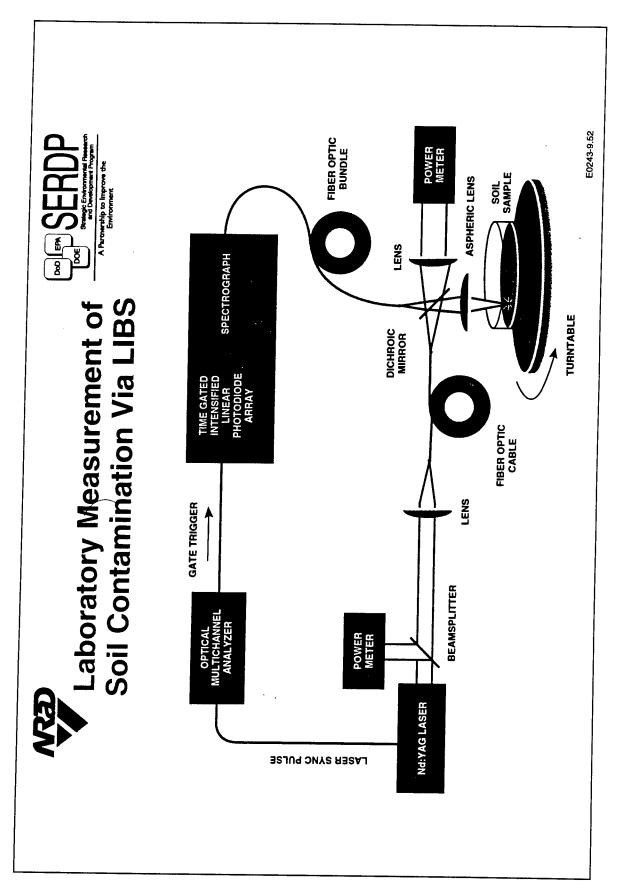
 $\frac{0.75 \times 10^{-3} \text{J}}{9 \times 10^{-9} \text{s} (\pi) (75 \times 10^{-4} \text{cm})^2} \stackrel{\leq 0.5}{\sim} \frac{\text{GW}}{\text{cm}^2}$

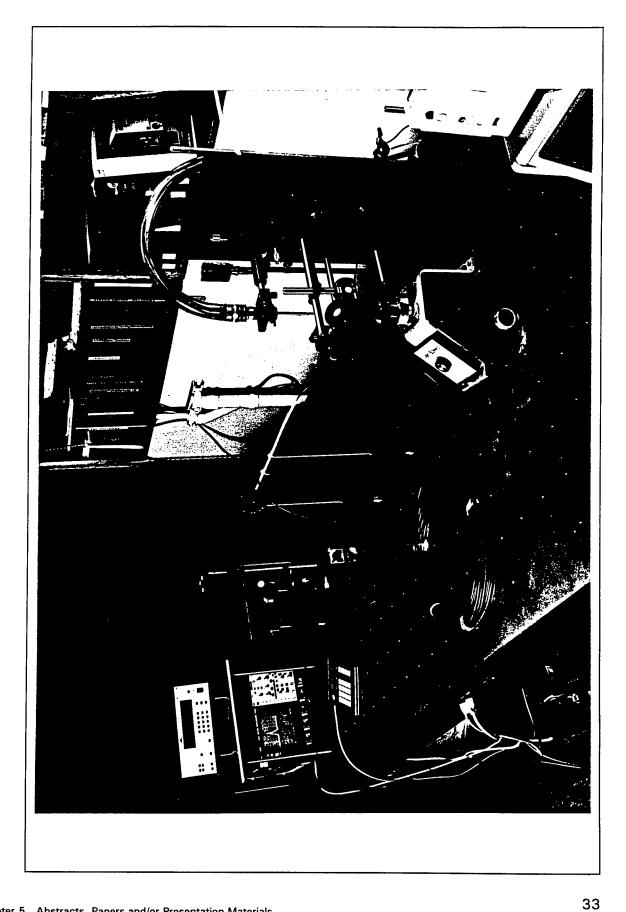
Soils Tested:
Guadalupe
Coronado I, II
Yuma
Alameda
Camp Pendleton
Fisher Sea Sand

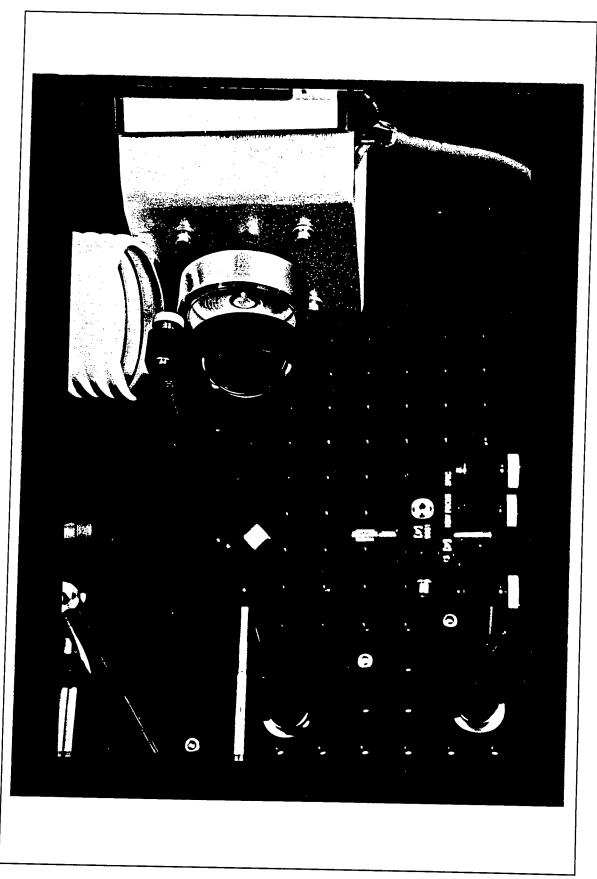
150 µ DIAMETER SPOT SIZE

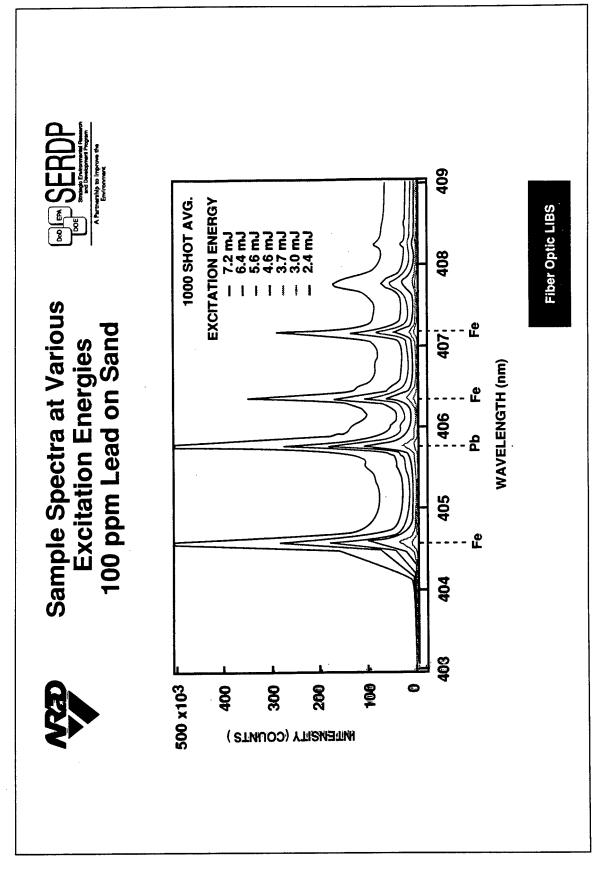
=10100.19 59

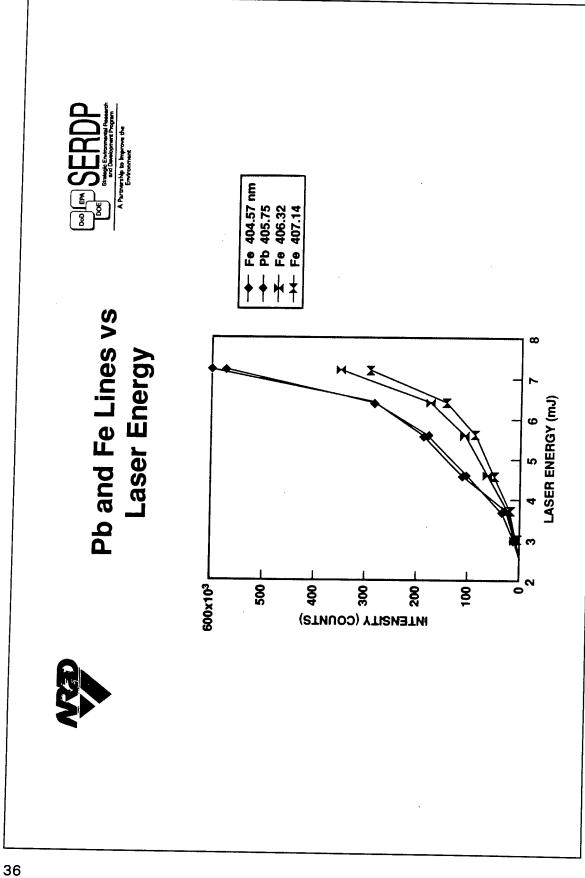










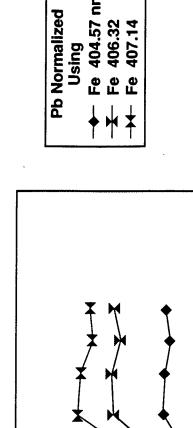




LASER ENERGY (mJ)

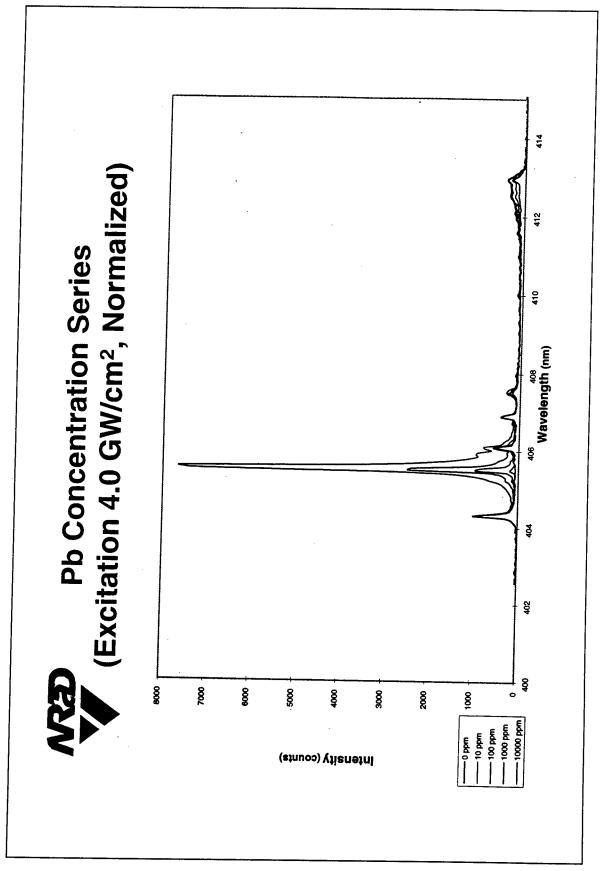


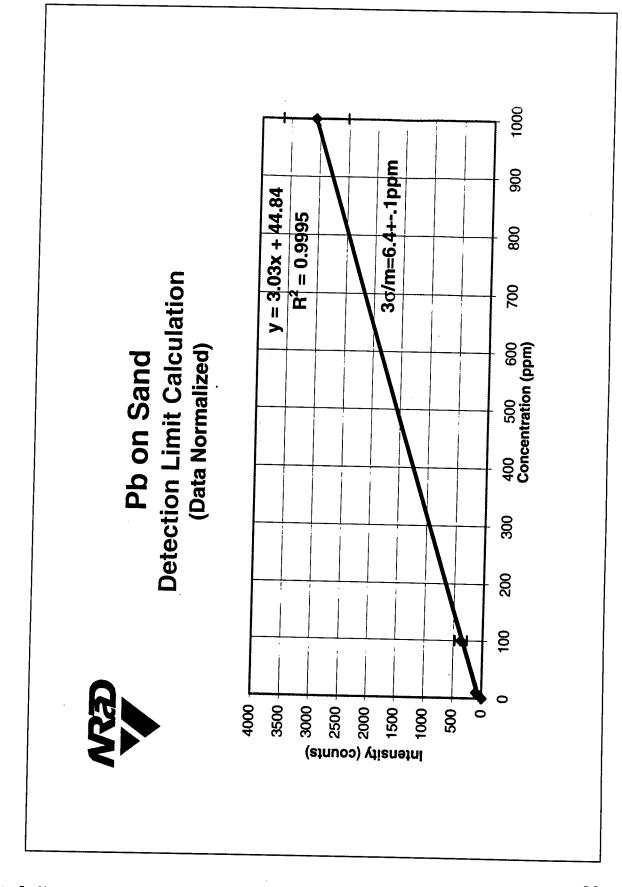
Pb/Fe Ratio vs Laser Energy

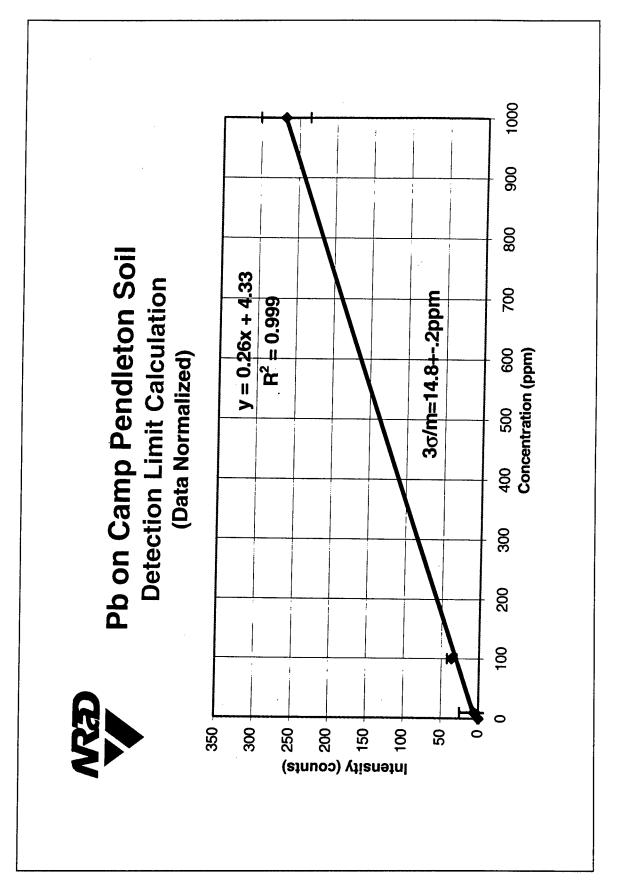


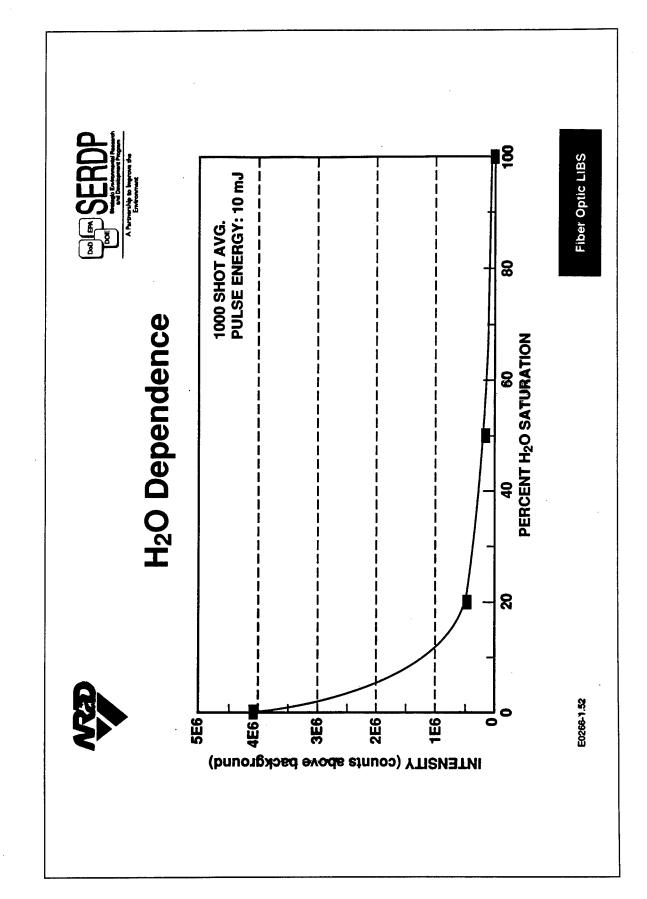
MORMALIZED PD INTENSITY

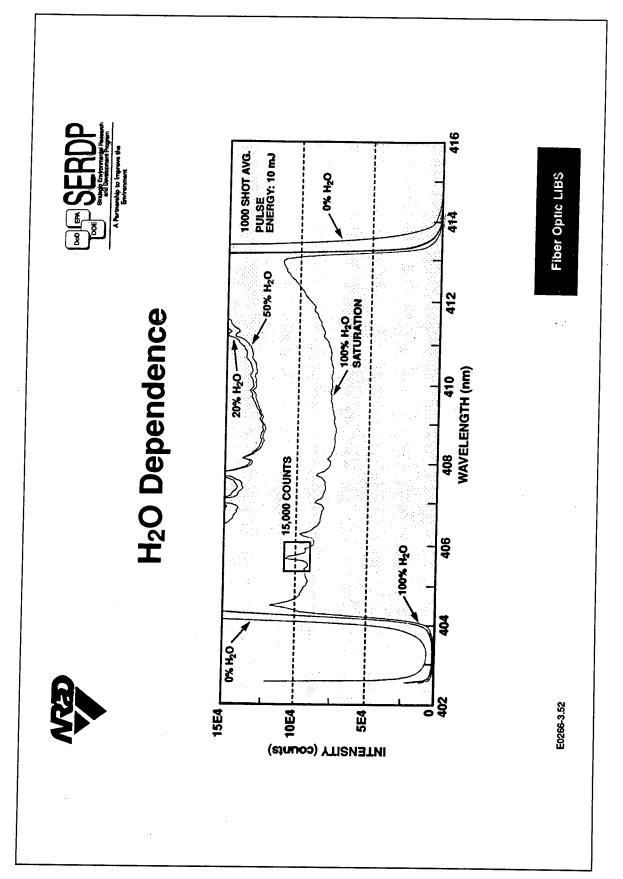








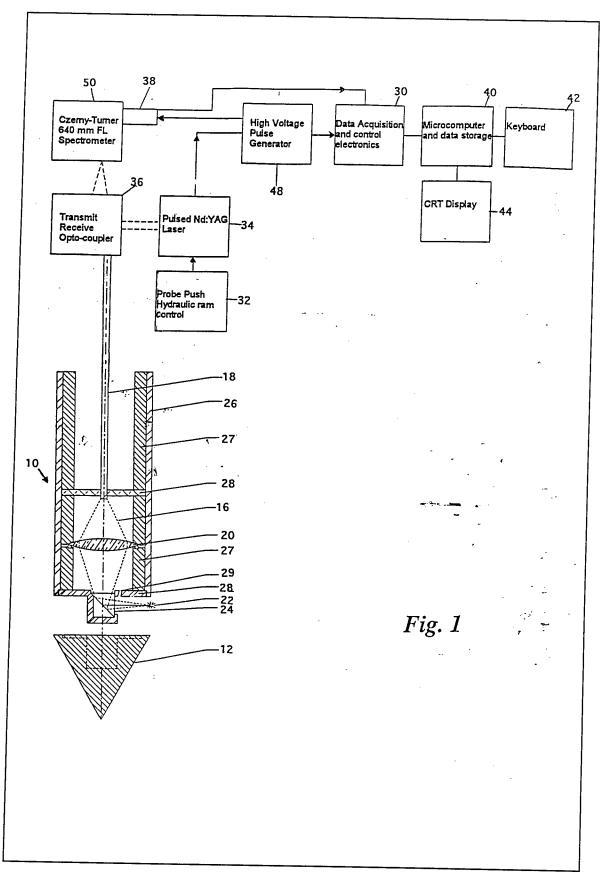


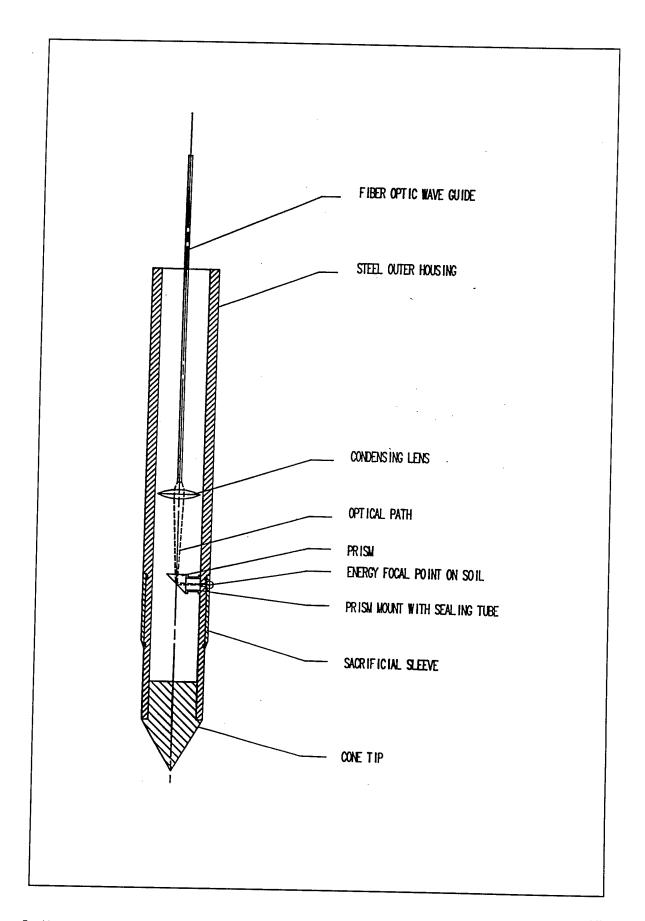




Conclusions

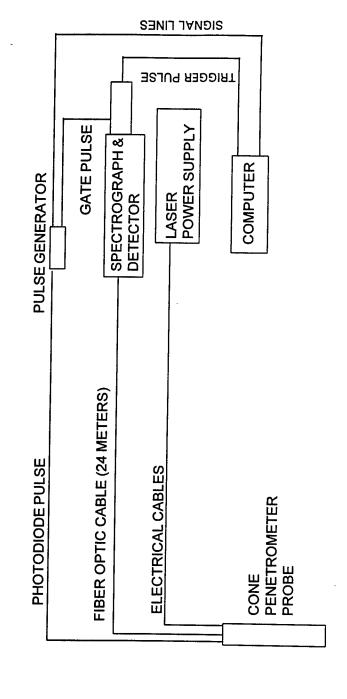
- Detection capabilities on the order of ppm are possible with FOLIBS on sands and natural soils
- Matrix effects due to H₂O and finer grain size reduce sensor response
- FOLIBS is possible over long lengths of fiber
- The FOLIBS laser power delivery system is robust





SCF SERDP LIBS Strategic Environmental Research A Partnership to Improve the Environment

SCHEMATIC OF THE LIBS ANALYZER FOR SCAPS





SYSTEM COMPONENTS



Laser KIGRE Nd:YAG Osc/Amp system >80 mJ/pulse; 6 nsec pulsewidth;

passively Q-switched; 1064 nm wavelength; 3-4 mm beam diam.; 1Hz

rep. rate; passive air cooling; 24 meter cabling

Spectrograph CHROMEX 250IS; 250 mm focal length; adjustable slits; 3600, 1200,

and 600 I/mm gratings; all spectrograph functions are computer-

controllable

Fiber Optics Fused silica; 19 fiber bundle; circular-to-rectangular with CHROMEX

mount; 24 meters long

Detector ORIEL InstaSpec V; gated intensified CCD; 10nsec minimum

pulsewidth gate; 10 Hz data acquisition rate; 25 mm CCD; 18 mm

diam. intensifier; 650 pixels active

Gate/Trig Pulse Compact, LANL built

Generator

Computer 486 IBM Compatible

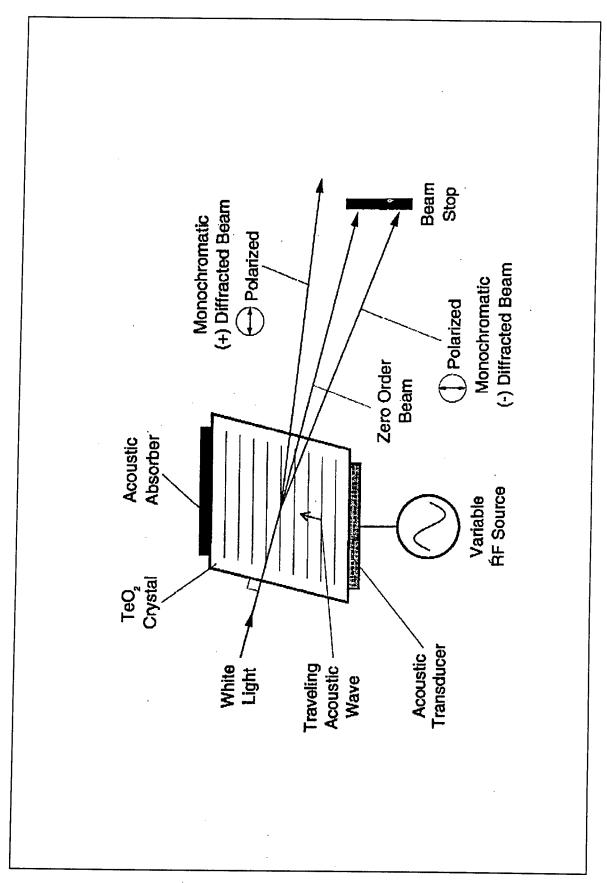
Software SPECTRA © --LANL developed spectral analysis software



PRESENT STATUS OF PROJECT



- Software completed
- CHROMEX, fiber optics, and computer on hand
- Delivery of laser by 31 August 95
- Detector delivery by 11 September 95 (use Insta Spec IV loaner in interim)
- System completed by 30 September 95



ACOUSTO OPTIC TUNABLE FILTER

Serial No.: 9506-AO-960

	SPECIFICATIONS	TEST DATA
Wavelength Range	380-600 nm	380-600 nm
Spectral Resolution (Å)	2 @ 380 nm 3 @ 600 nm	2 @ 380 nm 3 @ 600 nm
Corresponding Drive Frequency	200-350 MHz	218-434 MHz
Input/Output Polarization	Vertical	Vertical
Drive Power	1. Watt	1 Watt
Time Delay	10 μsec	10 μsec
Rise Time	30 µsec	30 µsec
Package Type	Air Cooled	Air Cooled
RF Connector	SMA	SMA



5020 campbell blvd., battimore, md 21236 usa • tel: 410/931-7200 • fax: 410/931-7206 e-mall: office@brimrose.com

New Quartz AOTF

- Wavelength Ranges:

200-400 nm

- Spectral Resolution:

1/ @ 400 nm

0.3/ @ 400 nm

- Optical Aperture:

10 x 10 nm

- RF Frequency:

95-200 MHZ

- Driving Power:

8 Watts

- Input/Output Pol.:

Vertical/Horizontal]

- Diffraction Eff.:

> 50%

- Time Delay:

 $30 \mu s$

- Rise Time

 $30 \mu s$

- Package Type:

Air Cooled

- RF Connector:

SMA

PROGRESS

Yet to be Accomplished

- Compare quality of LIBS spectra between OMA and AOTF e.g. for Pb lines around 400 nm.
- Establish whether single-photon counting using AOTF on and off resonance at 10+ microseconds yields advantageous S/N ratios.
- Time-resolved studies of plasma evolution.

Characteristics

- Solid State Device, Compact (cm³) and Ruggedize Moving Parts
- Fast Tuning Speed (several μ s to tens of μ s)
- Random Wavelength Access/Hopping
- NO "dead spectral space" for KHz Rate LIBS
- Simultaneously Multiple Wavelength Meassurement
- Spectral Imaging
- Built-in Solid State Chopper for Lock-in Amplification

PROGRESS Equipment Acquired

- "Ultra-High Resolution" AOTF, State-of-the-Art commercial unit Spectral resolution ca. 0.3 nm
- Compact and portable Nd:YAG Laser (Big Sky Laser Model CFR 200-20 with mini CE portable power supply)
- 4-channel digital scope (LeCroy Model 9354TM-500MHz) with 500 Ms/s and 500K point record length/channel.



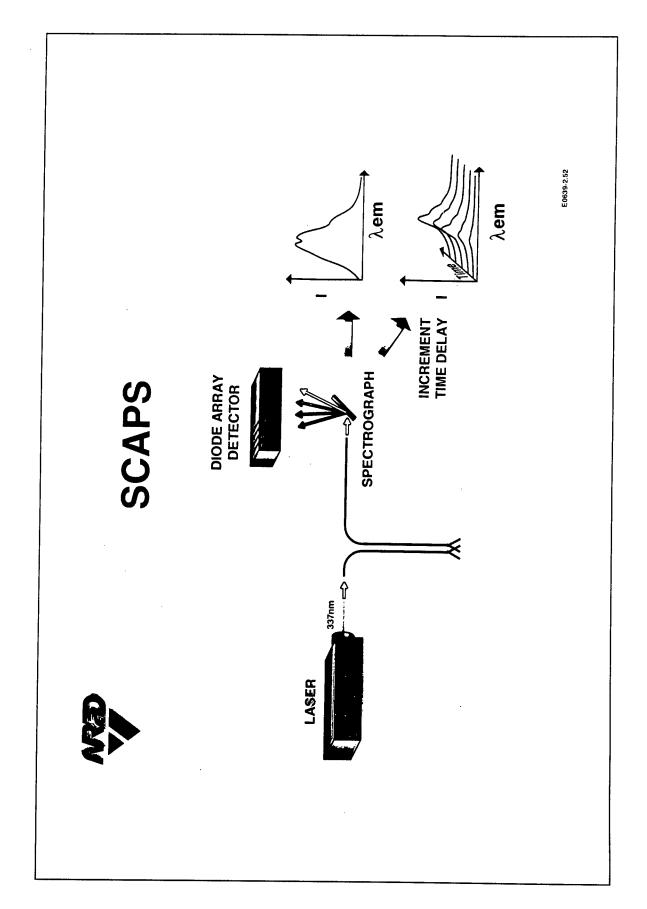
RESEARCH AREA II LIF SENSOR

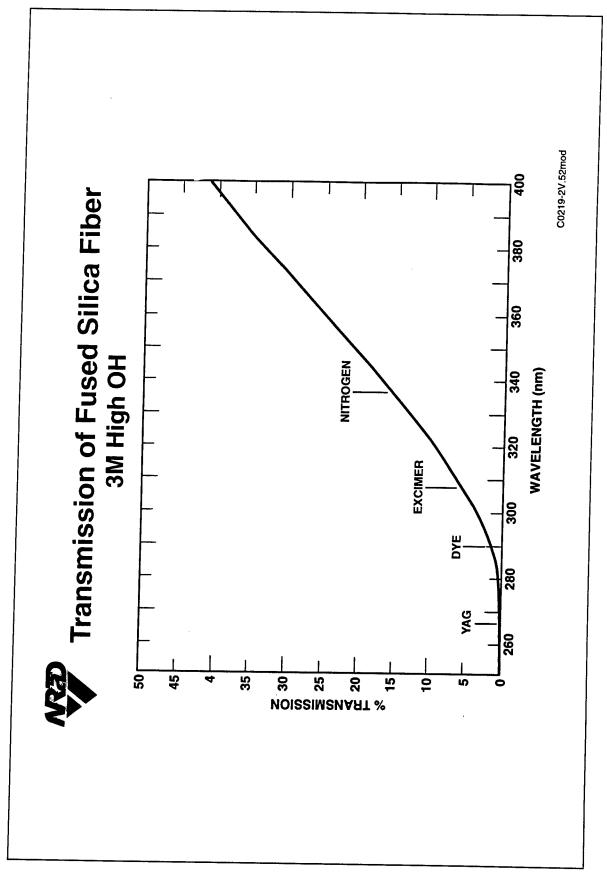


Comp

Reschd

Schd		ensor 03/95	POL sensor 03/96		explosives	09/95	96/60	12/96
Milestones	LIF POL Sensor	 Complete development of improved POL sensor 	 Complete field demonstrations of improved POL sensor 03/96 	 Photofragmentation/LIF Explosives Sensor 	 Demonstrate feasibility of PF/LIF for in situ explosives 	sensor	 Complete prototype sensor 	 Complete field tests of explosives sensor









XeCl Excimer Laser

wavelength:

308 nm

pulse energy:

2 mJ

repetition rate:

100 Hz

Gas:

99.7% He

0.07% HCI

0.2% Xe

• Laser pulses per fill: 3,000,000

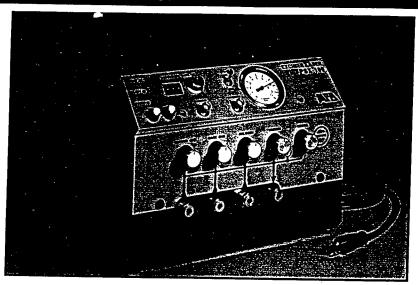
(8 hours or roughly 16 pushes)

Fills per bottle of gas: ~100



PSX-100 Excimer Laser

MPB TECHNOLOGIES INC.



The Model PSX-100 is an innovative multi-gas excimer laser which is both compact and portable and yet is capable of mJ pulse energies and, with a pulse duration of only 2.5 ns, peak powers in excess of 2 MW.

Both the laserhead and the power supply are incorporated in a single unit less than 1 ft. in length. The laser operates in a sealed-off mode and, despite its small gas volume, exhibits very respectable gas fill lifetimes even without the use of a gas processor.

The PSX-100 has been carefully engineered throughout, from its high-efficiency discharge circuit (with negligible reverse aftercurrent) to the use of high-quality, durable discharge circuit components and the careful selection of halogen compatible materials for the gas and discharge chamber.

Given its pulse energy and peak power capabilities, the PSX-100 represents a convenient and cost effective alternative to larger, much more costly lasers for many photoablation and micromachining applications. In addition, the laser's 2.5 ns pulse duration, unique among available excimer lasers, offers new possibilities in areas such as relaxation time studies and time resolved spectroscopy.

With its sealed-off mode of operation, air cooling and low power budget (100 W), the PSX-100 is also ideally suited for field use outside the laboratory.

Features

- · Compact single unit construction
- Air cooled
- · Short, high peak power pulses
- Efficient discharge circuit with negligible reverse aftercurrent
- Long thyratron life (> 3 x 10⁸ pulses)
- Halogen compatible construction for minimal repassivation
- Multi-gas optics (optional)
- · Automatic gas refill (optional)

Applications

- · Photoablation and micromachining
- · Semiconductor processing
- Surface analysis
- Laser ionization mass spectroscopy
- Fluorescence spectroscopy
- Photochemistry
- · Relaxation time studies
- Nonlinear optics



CANADA WARDATOF BUNIAN FACELLIACE Latterpressure-hip ten Internation 1988









SCAPS using Excimer laser

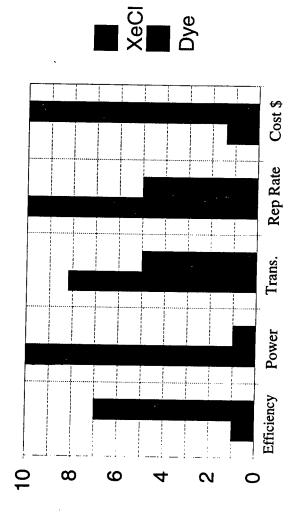
Advantages

- Nitrogen laser can be directly replaced by excimer laser without changes to detection system/software
- Less gas required compared to Nitrogen system

Disadvantages

 Added complexity working with toxic gases (small amount of HCl in excimer gas)

Detection of JP4 Dye Laser at 290nm - XeCl at 308nm







Excimer Laser Results

- integration into present SCAPS hardware straightforward
- laser very sensitive to gas contamination
 - operation ≤ 30 min per fill at present

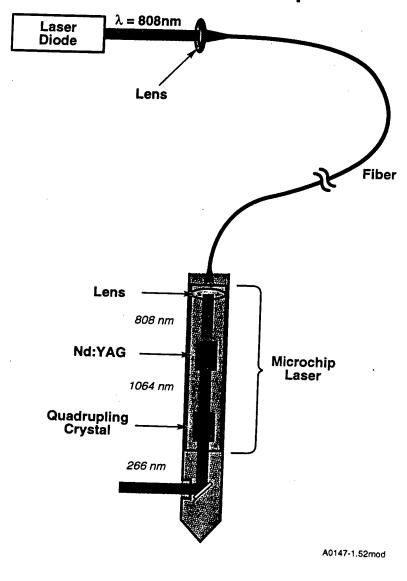
Timetable for fielding

• lab evaluation: Underway

• field testing: First Quarter FY 96



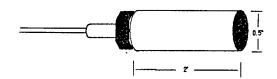
Schematic of Downhole 266 nm Wavelength Microchip Laser







Microchip Laser



wavelength:

266 nm

• power:

5 mW

pump source:

1.2 W laser diode

(located in truck)

• lifetime:

100,000 hours

material:

Nd:YAG

(all soild state; no gas required)

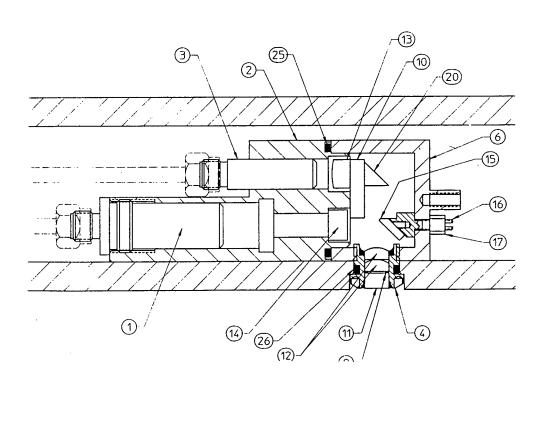
• source:

M.I.T. Lincoln Labs



Prototype Microchip Laser Probe

• Laser & collection fiber:







Microchip Laser Collaboration

Partners: NRaD, San Diego

MIT Lincoln Labs, Concord MA

- Lincoln Lab tasks
 - originally developed microchip laser (1064 nm)
 - frequency quadrupled output (266 nm)
 - frequency tripled output (355 nm)
 - designed mount for use in penetrometer
- NRaD tasks
 - integrate microchip laser into SCAPS
 - laboratory evaluation of LIF using 266 nm
 - field testing of SCAPS/microchip laser system
- Timetable

lab evaluation: Underway

- field testing: Second Quarter FY 96

CEX >

Lasers for LIF Sensor

Laser	Wavelength	Cost	i
nitrogen	337	8	ľ.
XeCl	308	12	
Tuneable (ROST)	290 (variable)	100	
Lipstick Nd:YAG	598	8	



A Partnership to Improve the Environment

Accelerated Tri-Services SCAPS Sensor Development

Laser Induced Fluorescence and Fiber Optic Raman Sensors



Mr. Bruce J. Nielsen
Environics Directorate
Site Remediation Division

Laser Induced Fluorescence (LIF) and Fiber Optic Raman Sensors (FORS)

Objective: Perform Fluorescence and Raman Sensor R&D for SCAPS, Based on Tunable (ROST) Technology.

Approach:

- Provide for Refinement of Prototype Systems
- Test in Lab & Field Environments
- Determine Device Applicability

Payoff:

- Applicable to Site Characterization and Monitoring
- Accurate and Reliable Results
- In Situ, Real-Time Data
- Reduced Characterization and Monitoring Costs
- Remediation Process Control

Laser Induced Fluorescence Sensors

LIF POL Sensor

Principal Investigator: Dr Greg Gillispie Dakota Technologies, Inc./North Dakota State University

Emphasizes Use of Tunable Dye Laser

- Study Soil Matrix Effects on Fluorescent Properties of Aromatic Hydrocarbons
- Oxygenated Versus Deoxygenanted Matrices
- Laboratory Testing Indicates Detection of #2
 Diesel, DFM, Unleaded Gasoline, and JP-4 on Sand,
 Soil From China Lake, and Soil From Columbus AFB at 100 ppm or Lower Concentrations.

Laser Induced Fluorescence Sensors (cont.)

Research Questions:

- How Much Chemical Information Can Be Derived From Fluorescence Spectra?
- What Are the Detection Limits?
- How Linear Is the Calibration Curve?
- Deviations at Low and High Concentration Ends?
- Can Dissolved Phase Aromatic Hydrocarbons Be Detected?

Laser Induced Fluorescence Sensors (cont.) Results:

- Developed Apparatus/Method for Spiking Soil Samples
 - -- Teflon Containers/Paint Can Shaker
 - -- Nonstick Surfaces/Good Mixing
- Five Soil Types Spiked With Diesel Fuel
 - -- Sand Fluorescence Response 10X Silty Matrix
 - -- Sand Fluorescence Response 100X Peat or Lean Clay Matrix
- Will Collaborate with WES Matrix Study
 - -- Ten or More Soils
 - -- Four Common Fuels
 - --- Gasoline, Jet Fuel, Diesel #2, DFM

Laser Induced Fluorescence Sensors (cont.) <u>Tasks</u>

- (1) Pattern Recognition Techniques
 - Chemometrics (MATLAB Code to Analyze WTM Data)
 - Time Resolved Excitation Emission Matrices (TREEMs)
- (2) Lower Detection Limits by Better Probe Design
 - The Probe Design Will Be Carefully Reassessed to Better Reject the Scattered Exciting Light, Especially With Regards to Tunable System.
- (3) Lower Detection Limits, Improved Specificity by Time Gating
 - Characterize How Well a Gated-OMA Functions As Compared to an Emission Monochromator

Laser Induced Fluorescence Sensors (cont.)

<u>Tasks</u>

- (4) Downhole Frequency Doubling
 - Use Powdered Doubling Crystals
 - Proof-of-Concept Performed
 - Characterize and Optimize Doubling Process
- (5) Alternate Wavelength-Selectable Laser Sources
 - Raman Shifters
 - Optical Parametric Oscillators (OPOs)
 - Ti:Sapphire



APPROACH



1. Laser Photofragmentation

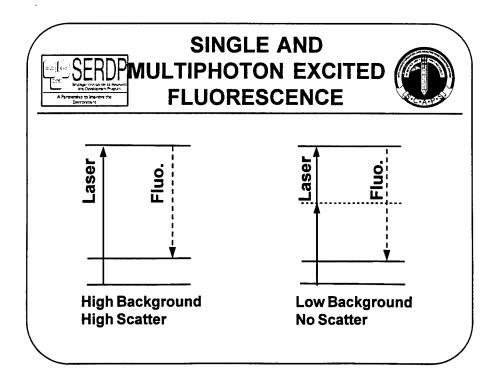
$$R-NO_2 \xrightarrow{hv_1} R + NO_2$$

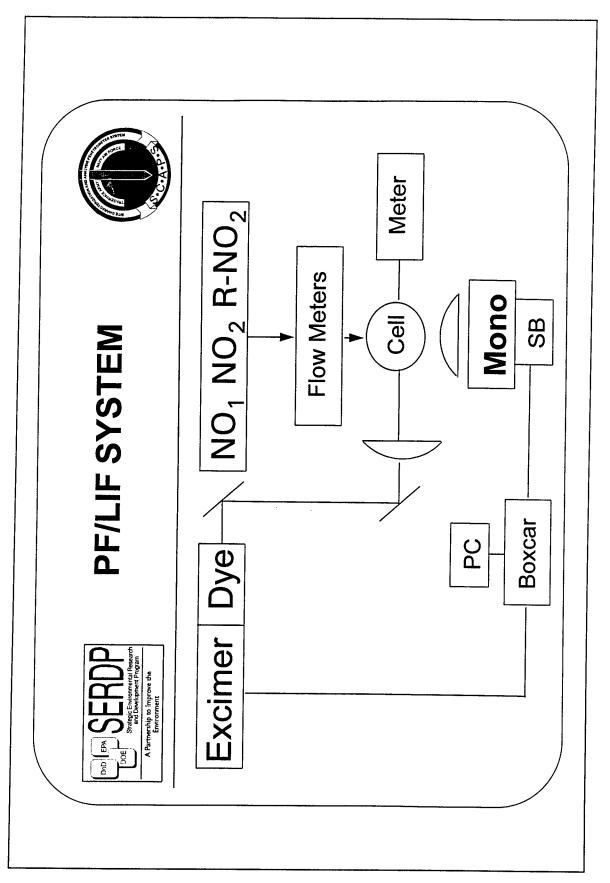
2. Fragment Detection

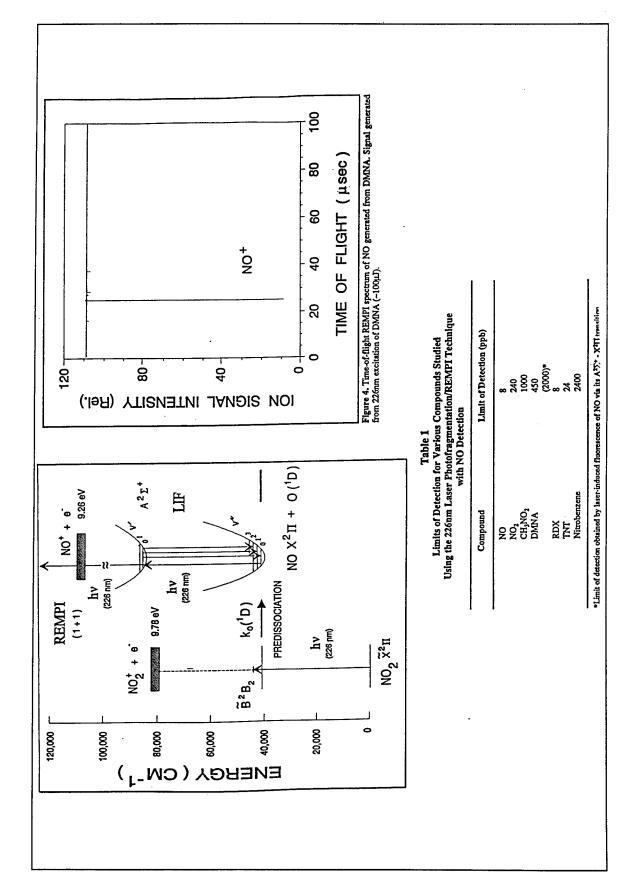
$$NO_{2} \stackrel{h}{\smile} hv_{2} = NO^{+} + O$$

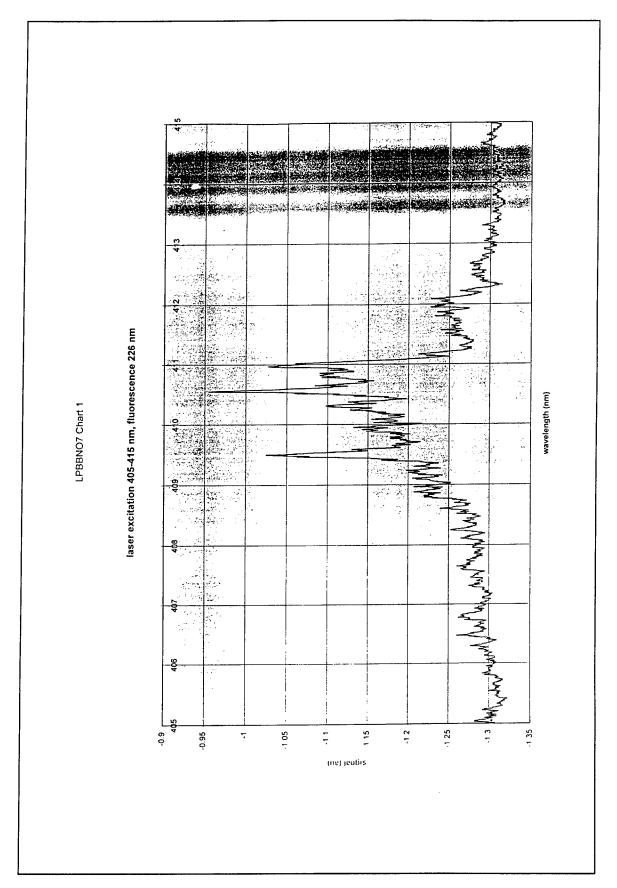
$$NO^{+} + O$$

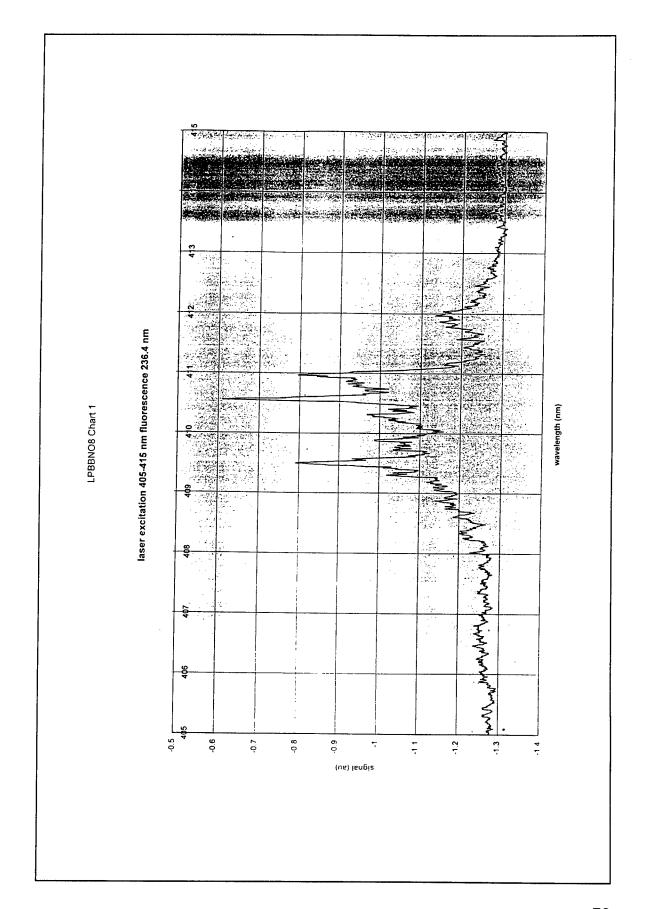
$$where hv_{1} = hv_{2}$$













SENSOR DEVELOPMENT WORKSHOP

29-30 August 1995

U.S. Army Corps of Engineers

Waterways Experiment Station

LASER-INDUCED FLUORESCENCE SENSORS

R.C Sausa
U.S. Army Research Laboratory
AMSRL-WT-PC
Aberdeen Proving Ground, MD 21005

Level of Support: FY94: 40K, FY95: 20K

OBJECTIVE Develop and Deploy Advanced Optical Sensors Based on Laser Photofragmentation Laser-Induced Fluorescence for Rapid and Real-Time Site Characterization and Analysis



LASER PHOTOFRAGMENTATION/ LASER-INDUCED FLUORESCENCE

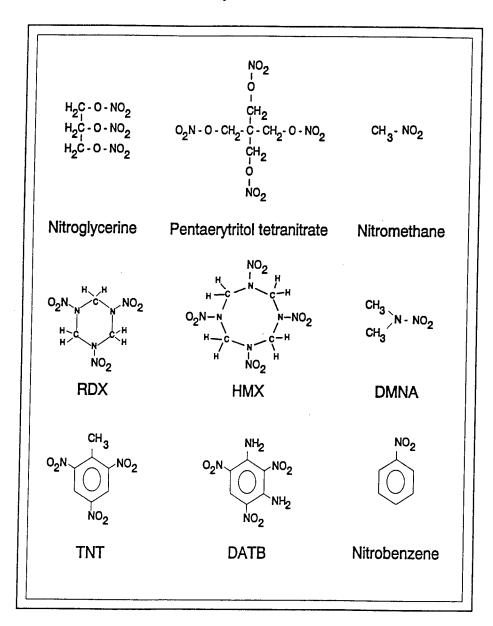
- * Utilizes one laser to both fragment the target molecule and detect the characteristic fragments by laser-induced fluorescence.
- * System utilizes an optical fiber to transmit the laser radiation and an interference filter/PMT combination or optical multichannel analyzer for detection.

TECHNICAL PROGRESS

(Accomplishments)

- Designed & constructed LP/LIF cell
- Performed literature search. Reviewed pertinent papers & started writing review article on laser-based techniques for detection of nitrocompounds including energetic materials (analytical chemistry)
- Determined LODs of various nitrocompounds using LP/one-photon LIF of NO (a-x)(0,0) band near 26 nm
- Determined LODs of NO & NO₂ by twophoton LIF of NO (a-x) transitions using laser radiation near 452 nm
- Wrote & tested multi-parameter computer program for spectral simulation of NO (a-x) band
- Initiated system design of prototypical system established contact with WES for field testing/use
- Three open literature







APPROACH

1. Laser Photofragmentation

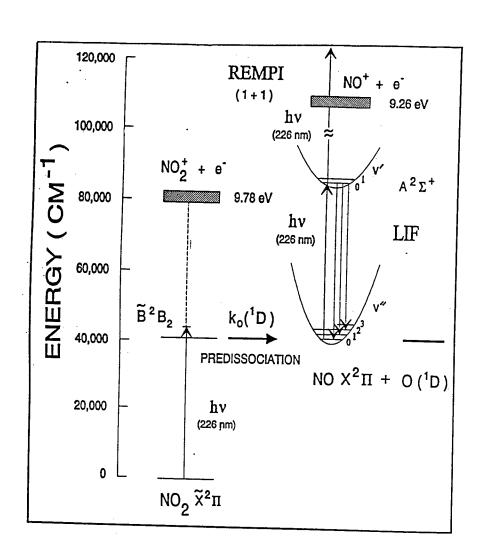
$$R-NO_2 \xrightarrow{hv_1} R + NO_2$$

$$NO_2 \xrightarrow{hv_2} NO + O$$

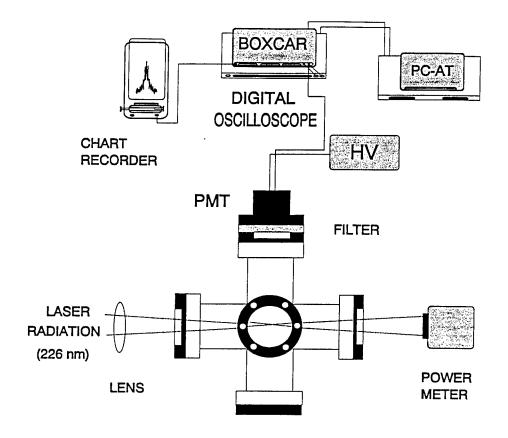
2. Fragment LIF Detection

$$NO \xrightarrow{hv_3} NO^*$$

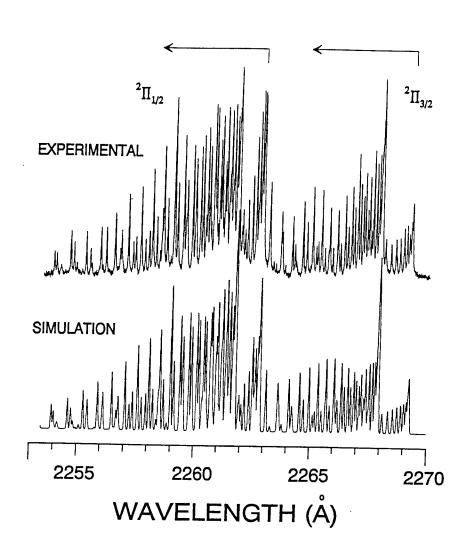
where
$$hv_1 = hv_2 = hv_3$$



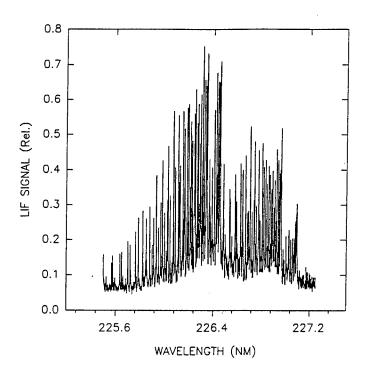




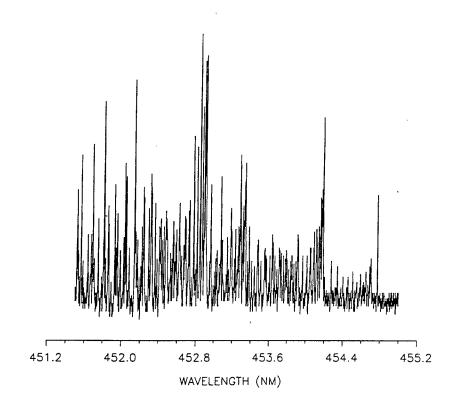












Limits of detection for various nitrocompounds studied using the technique of laser photofragmentation/ NO fragment detection by REMPI-TOF.

Compound	Limit of Detection (ppb)
NO	8, (1) ^a
NO ₂	240, (22) ^a
CH ₃ NO ₂	1000, (220) ^a
DMNA	450
DIVINA	(2000) ^b
RDX	8
TNT	24
Nitrobenzene	2400

a LODs obtained by NO REMPI using a pair of miniature electrodes.

LOD obtained by LIF via the NO $A^2\Sigma^+-X^2\Pi$ (0,0) transition.

PROPOSED RESEARCH

FY96 - 130K (Labor, 110K, ½ manyr + postdoc, Equipment, 20K)

- Designed and construct prototypical system to couple with penetrometer probe
- Laboratory test, evaluate, and optimize system using site samples
- Field test sensor at sites designated by WES

ACKNOWLEDGEMENT

- * Dr. Robert Pastel, U.S. Army Research Laboratory Postdoctoral Fellow.
- * Professor Josef Simeonsson of the University of Iowa, Department of Chemistry.
- * Dr. Ernesto Cespedes of the U.S. Army Engineer Waterways Experiment Station.
- * Strategic Environmental Research Development Program on Site Characterization and Analysis Penetrometer System.



RESEARCH AREA III FOR SENSOR



Selones	2420	7000	(
		Rescud	Comp
Complete development of laboratory FORS system	03/94	08/07	70/00
Complete characterization		46/00	00/94
campion of detection capabilities	09/94	12/94	12/01
Complete fabrication of prototype EODS	•	Ì	10/7
egold CVO Legold to the control of t	03/95		03/95
Complete design of resonance enhanced FORS probe	09/95		
Complete fabrication			
Complete labilitation of resonance enhanced FORS probe	12/95		
Complete FORS software development			
	03/86		
Complete field demonstration of resonance enhanced			
TOKS probe	96/80	01/97	



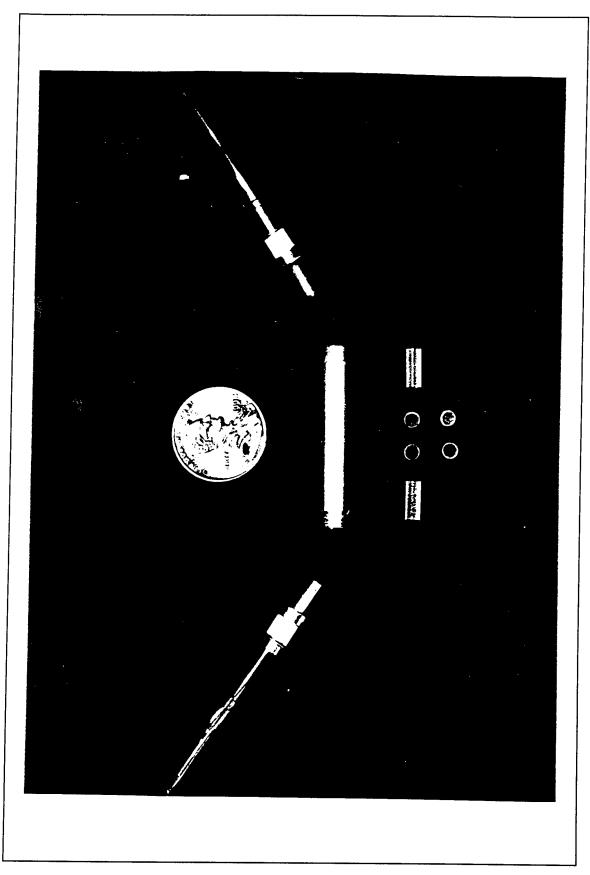


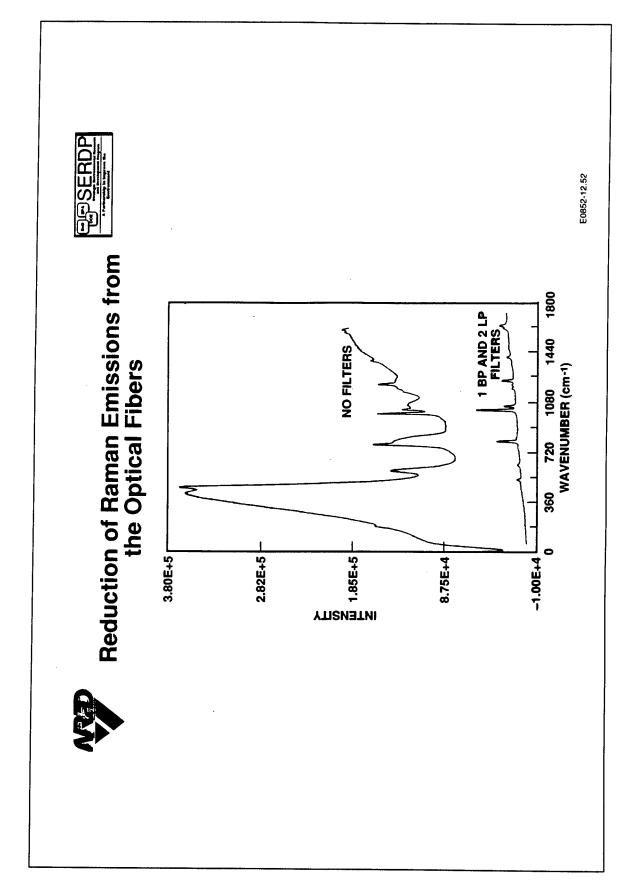
Advantages of Fiber Optic Raman Spectroscopy

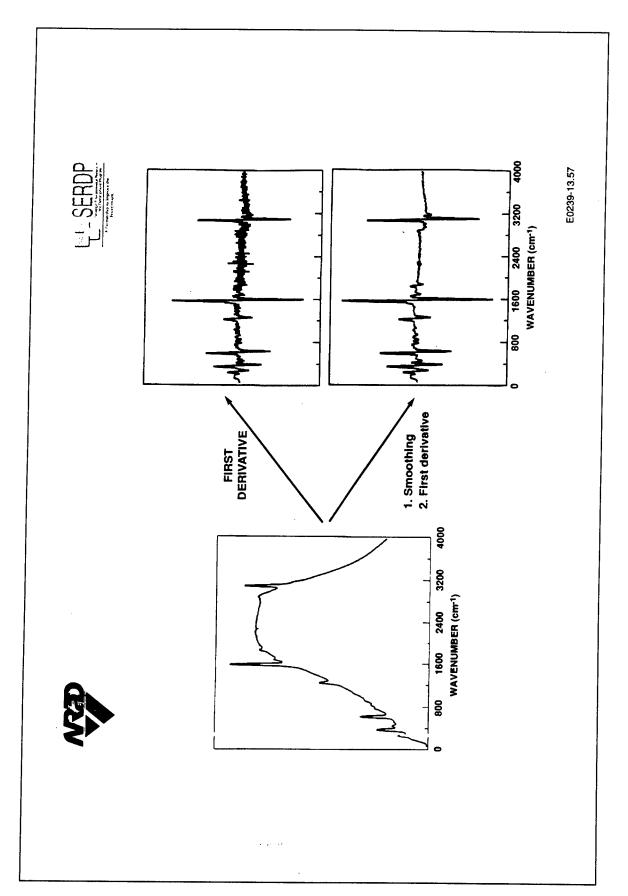
- 1. Specificity
- Simultaneous multicomponent analysis
- Minimal Raman interferences from matrix
- 4. Remote
- 5. Real-Time 6. In-situ

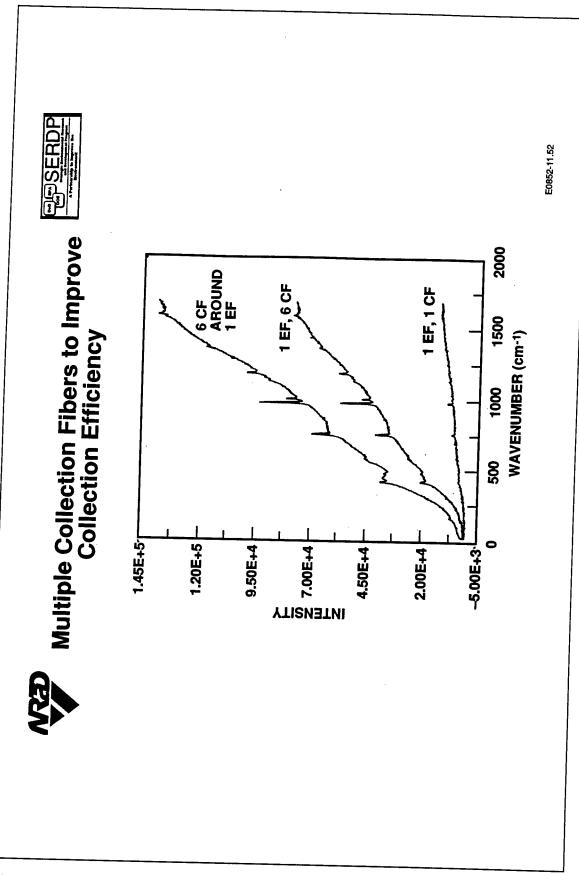
Technical Challenges

- Interferences due to Raman emissions in optical fibers
- Fluorescence interferences from matrix
- Low sensitivity





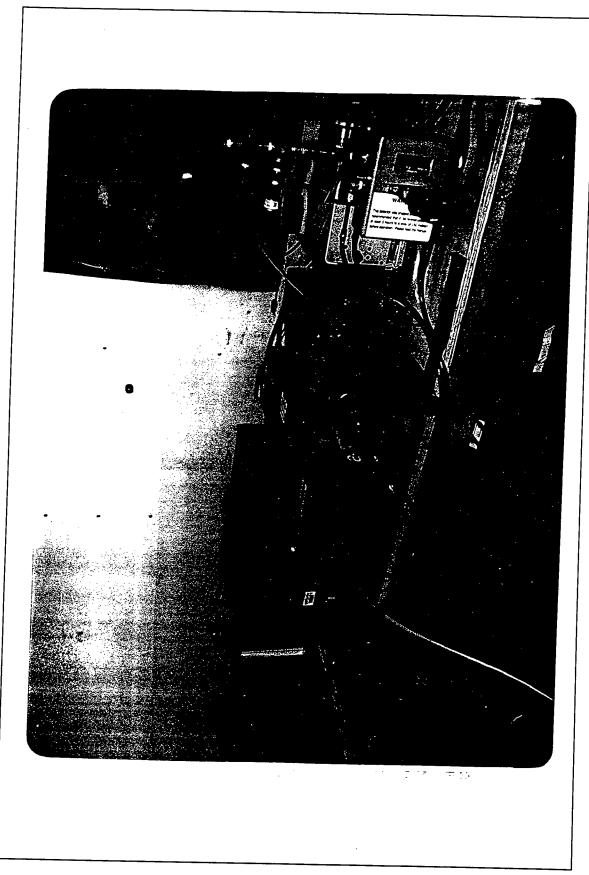


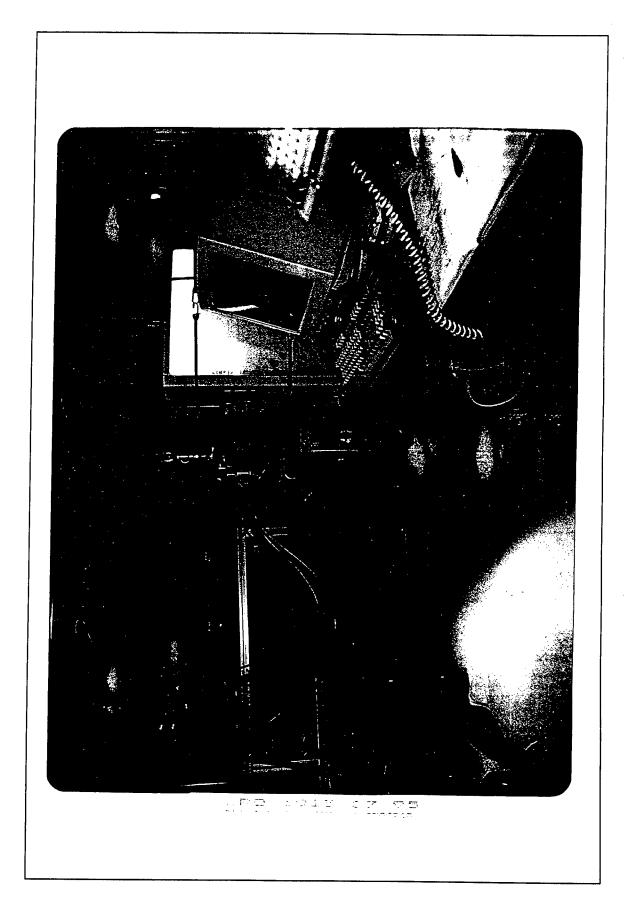


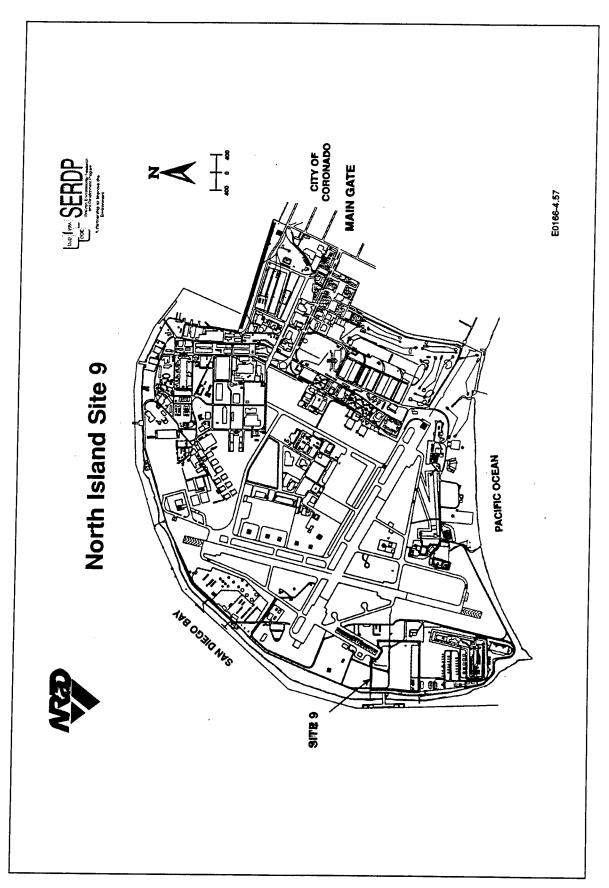


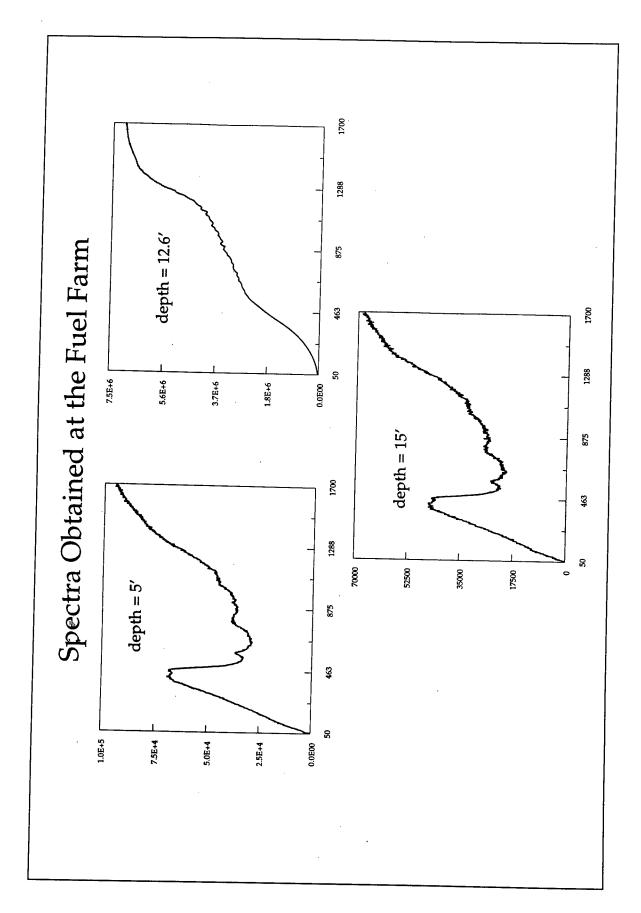


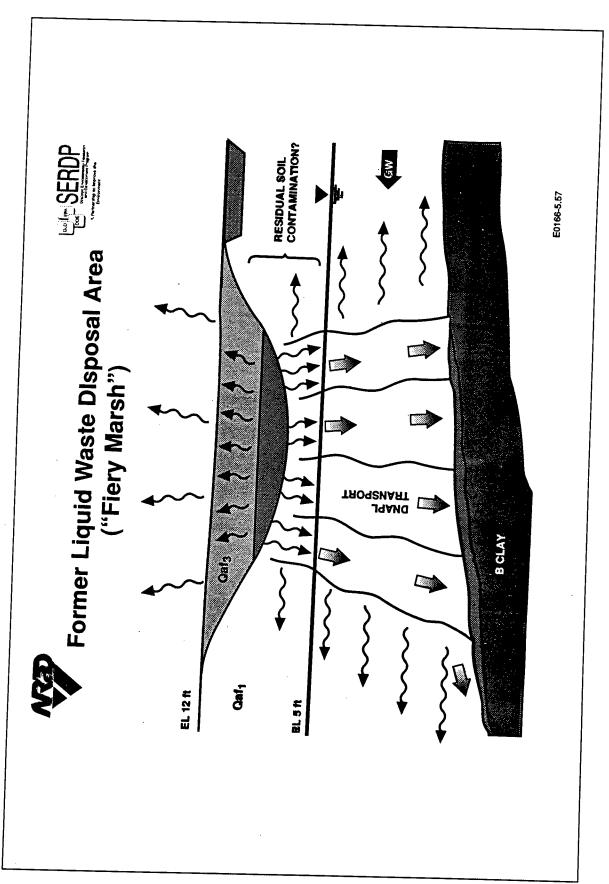


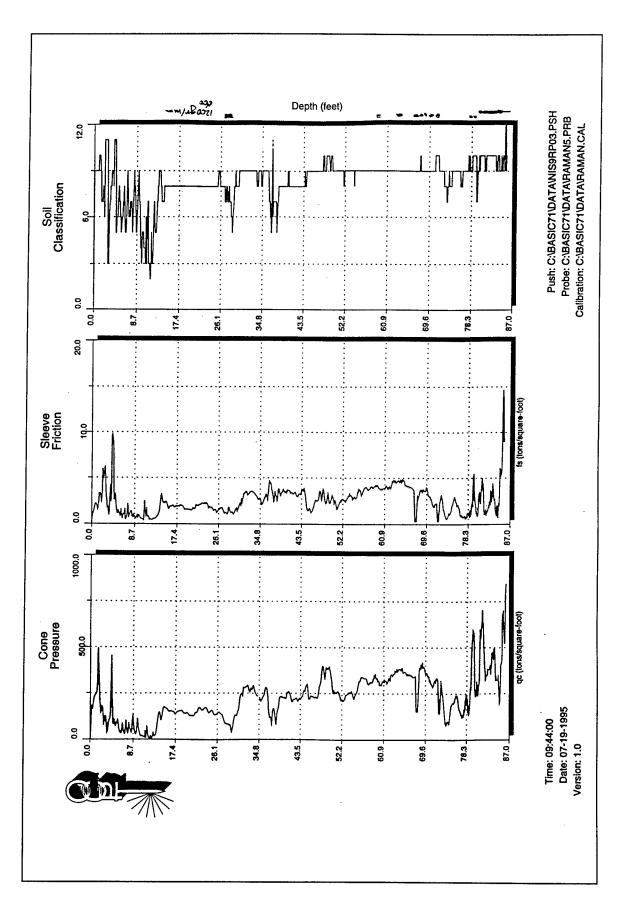


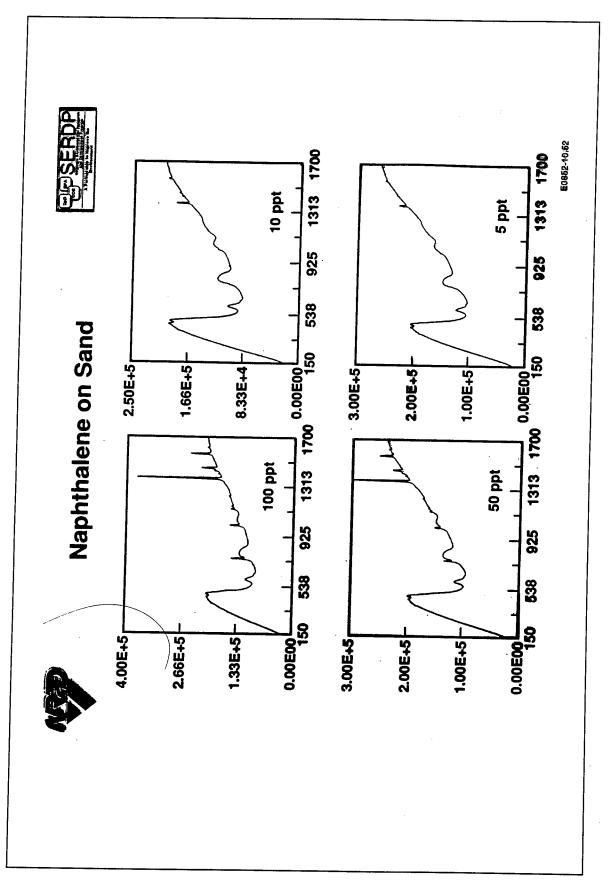


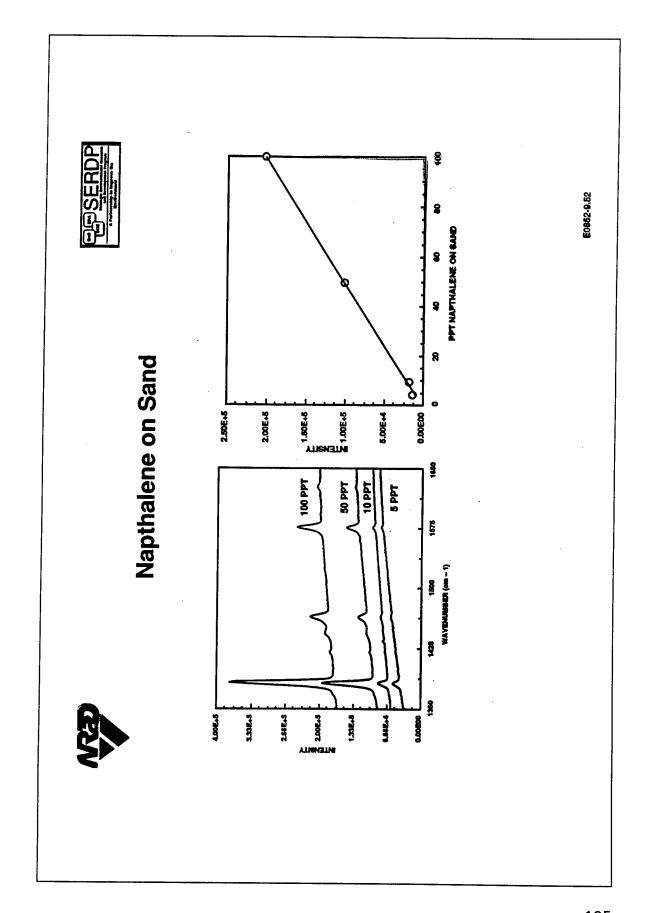


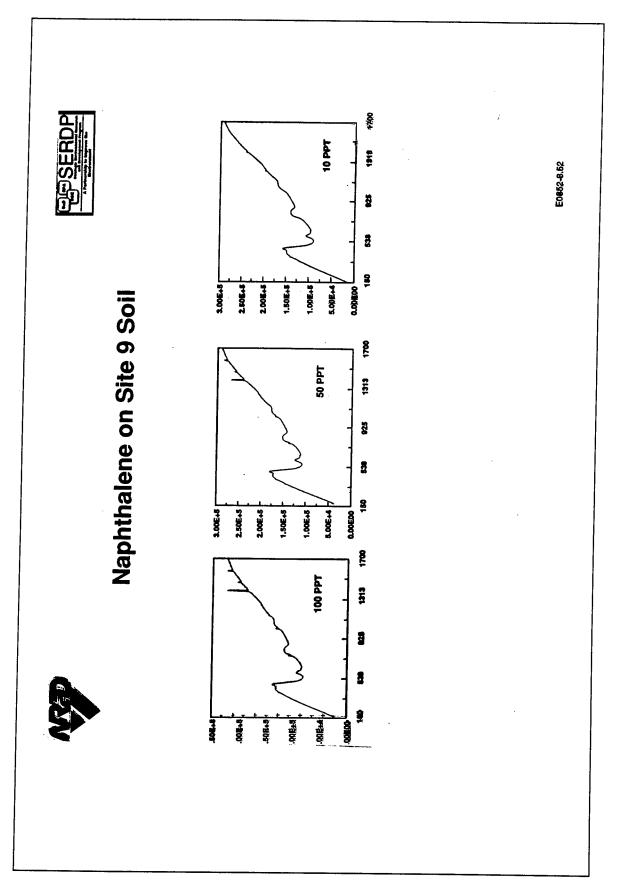


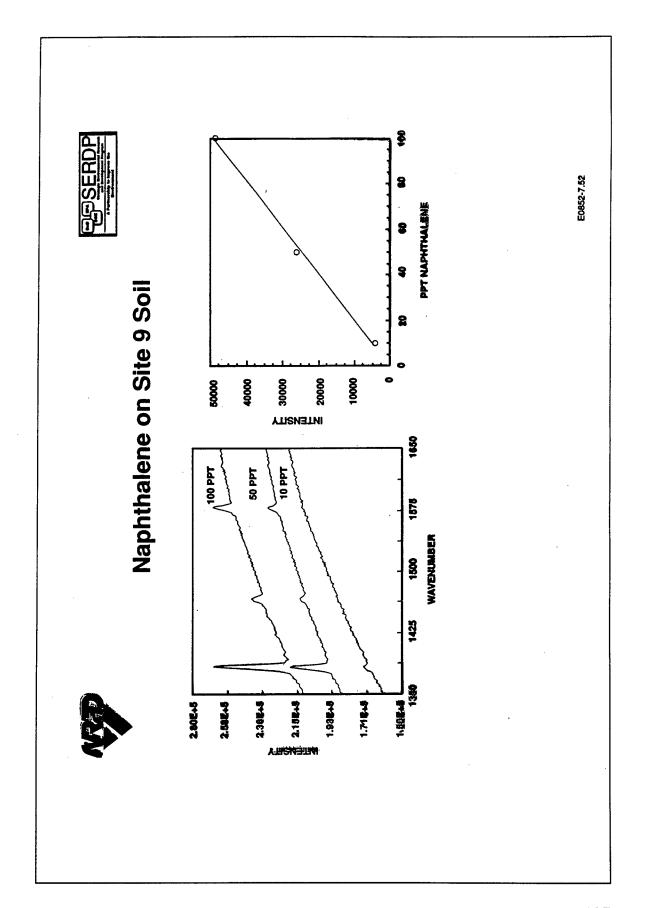


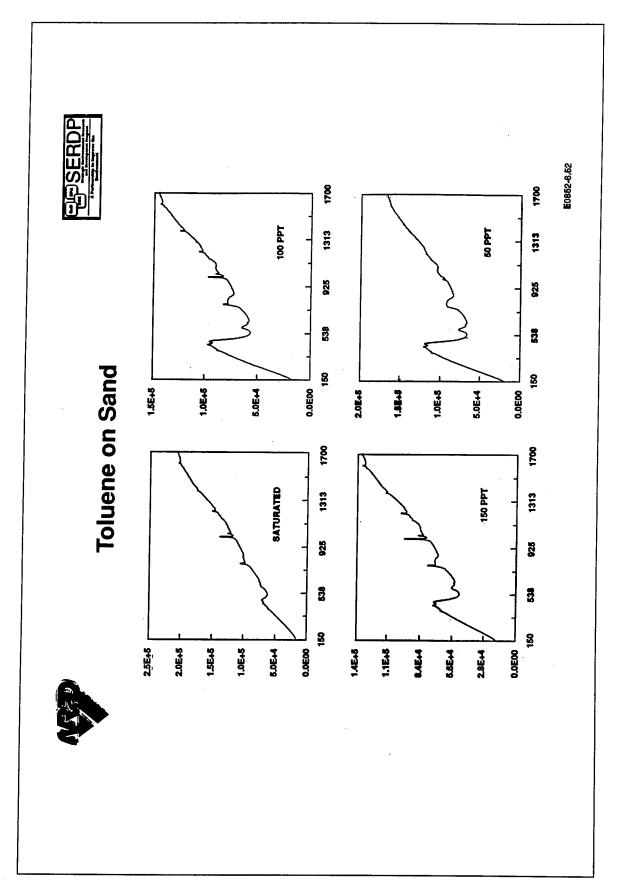


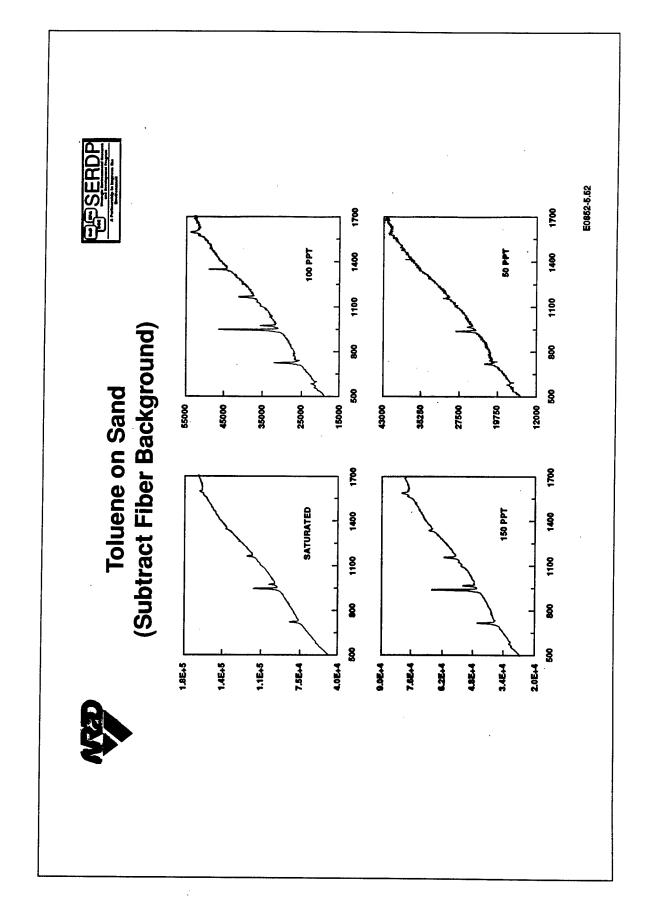


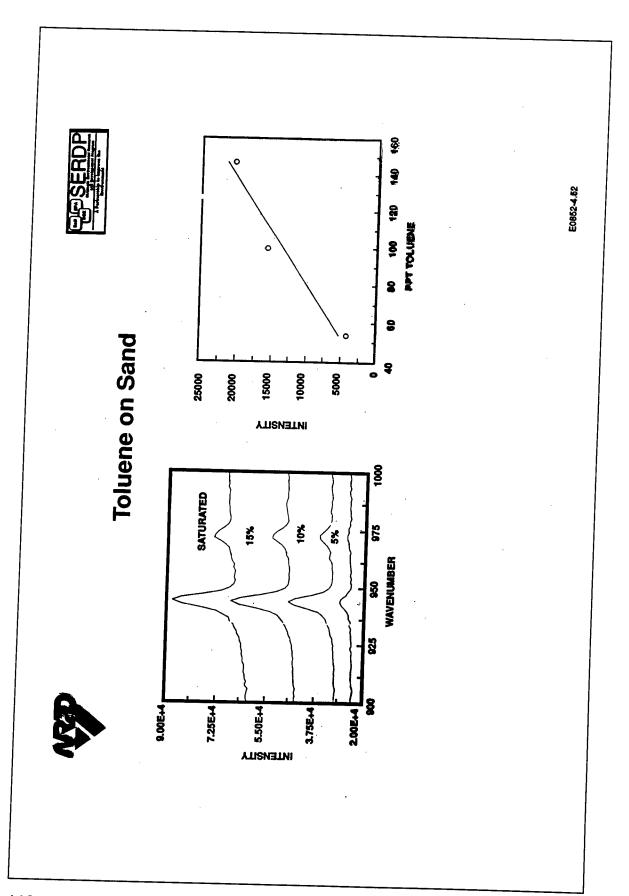


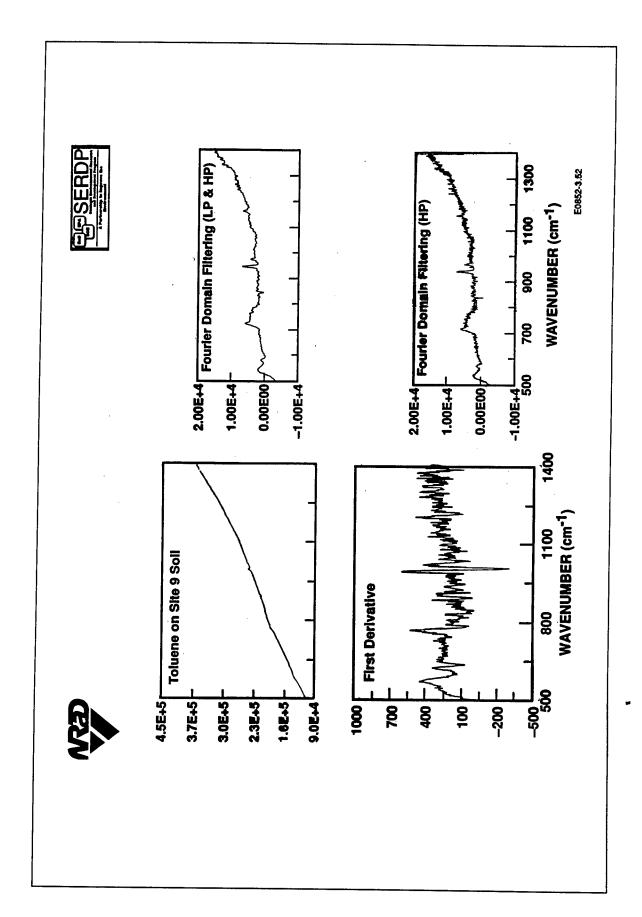


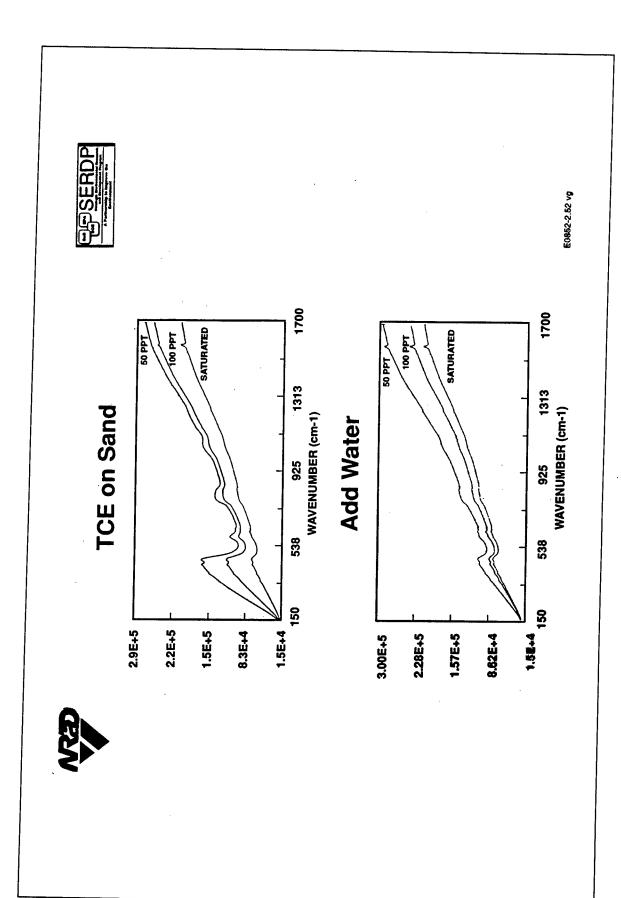


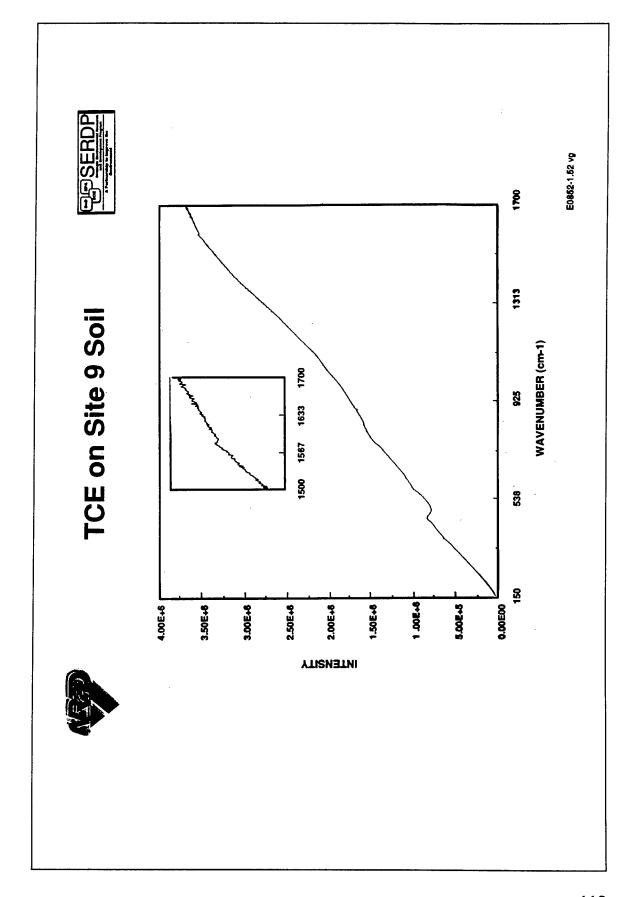












FLUORESCENCE

- 1. Near IR Excitation
- 2. Pico-second Raman Spectroscopy

LOW SENSITIVITY

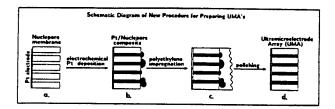
- 1. Resonance Raman Spectroscopy
- 2. Surface Enhanced Raman Spectroscopy (SERS)

SURFACE ENHANCED RAMAN SPECTROSCOPY

Compound	Method of Adsorption	Substrate	Excitation (nm)		
benzene	electrochemical	Ag	488, 514.5, 670		
toluene	electrochemical	Ag	514.5		
nitrate	electrochemical	Ag	670		
TCE	electrochemical	biphase Cu	647, 676		
TCE	1-octadecanethiol	Ag	647		
benzene	1-octadecanethiol	Ag	647		
xylenes	1-octadecanethiol	Ag .	647		
benzene	low temperature, 150K	Ag	488		

Ultramicroelectrodes (UME):

- 1. Diameters less than 20 microns
- 2. Fast response time
- 3. Diminished Ohmic losses





Fiber Optic Raman Sensors

FOR Solvent Sensor

Principal Investigator: Dr Greg Gillispie, Dakota Technologies, Inc./NDSU

Resonance Raman Approach

- Requires Tunable Laser or Multiple Wavelengths
 - Proof-of-Concept Provided for TCE Detection

Raman Studies

- Use Nitrogen Laser With Subnanosecond Pulse
 - Study Water Raman/Fluorescence Ratio

Raman Shifter Studies

- Vibrational and Rotational
- -- Function of Gas, Pressure, and Pump Energy -- Closely Spaced Output Lines in Ultraviolet
 - Use of Solid State (Salt Crystal) Raman Shifter
- Using System With HPLC for Chemometric Studies

Fiber Optic Raman Sensors (cont.)

Research Questions:

- Amount of Resonance Enhancement As Function of Excitation Wavelength?
- -- Use Raman Shifter
- Ability to Seperate Raman From Background Fluorescence Signal?
- -- By Excitation Wavelength, Time Gating, and Data Processing
- Substances to Be Studied:
- -- BTEX, PCE, TCE, DCE, Carbon Tetrachloride, Chloroform, Hexane, Cyclohexane

Fiber Optic Raman Sensors (cont.)

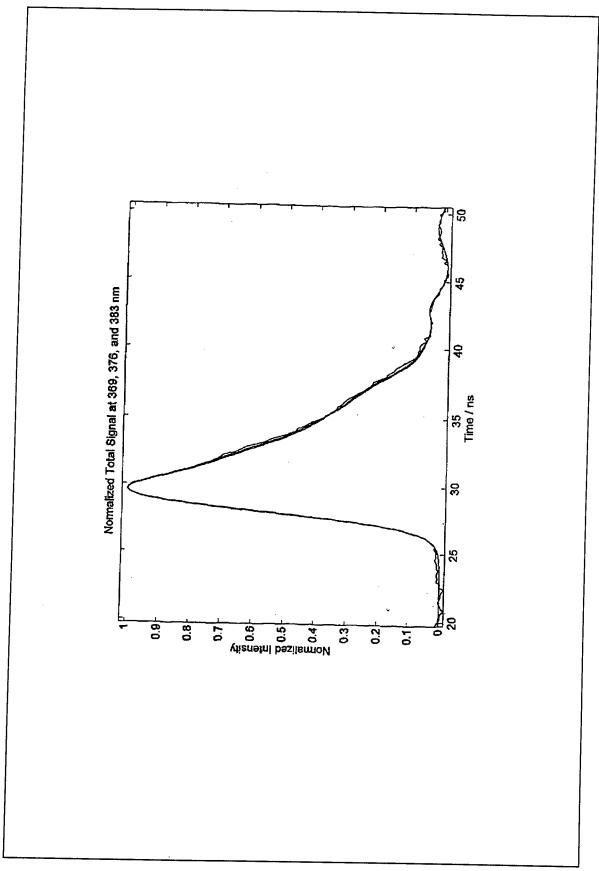
Tasks

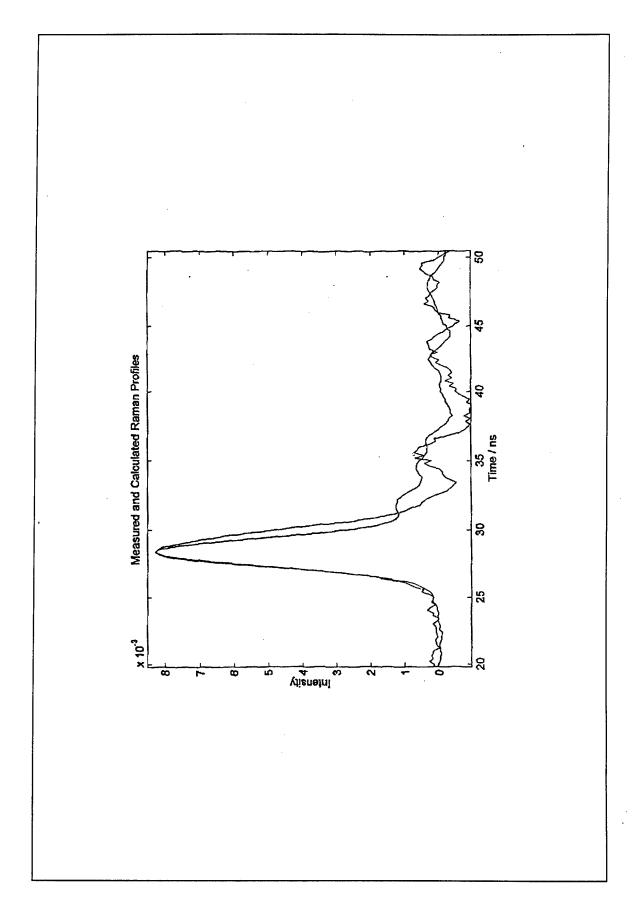
- (1) Characterizing Fibers
- Attenuation versus Wavelength
 - Interferences
- Fiber Transmission Times
- (2) Design Decision on Detector
 - PMT vs. CCD
- (3) Characterizing Wavelength Dependence of the Resonance Enhancement
 - Determine Optimum Wavelengths

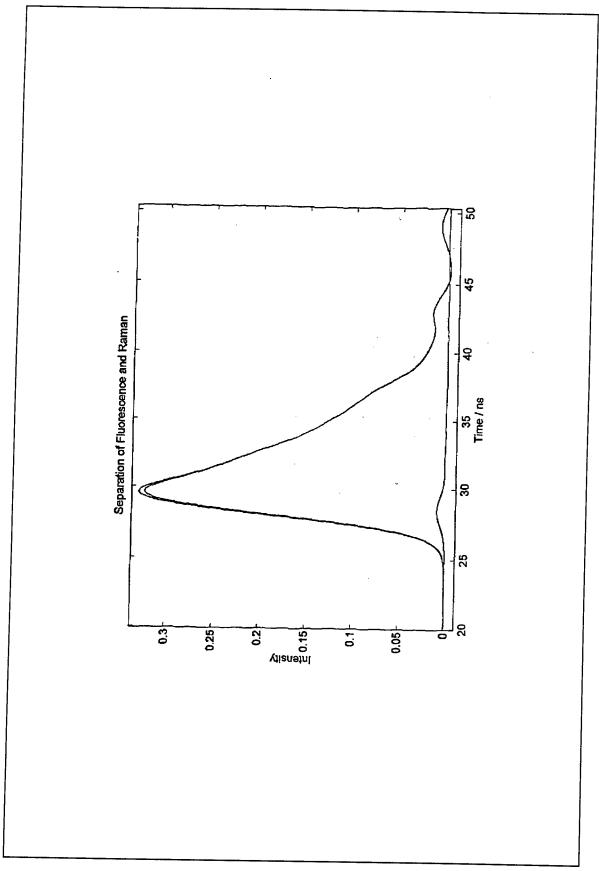
Fiber Optic Raman Sensors (cont.)

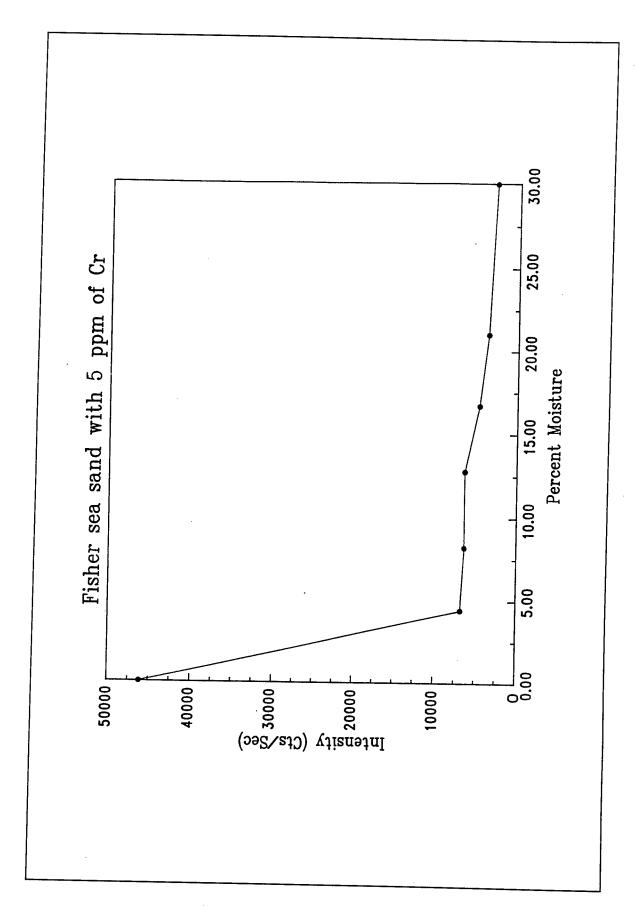
Tasks

- (4) Suppressing Background Fluorescence
- With Time Shifting Time Resolved Raman for Fluorescence Suppression -- The Raman Signal Is Coincident With the Laser Pulse
- (5) Wavelength Shifting of the Raman Excitation Source - For Fluorescence Suppresion
- Real-Time Processing of Raman Spectral Data (6) Development of Data Analysis Methods For











RESEARCH AREA IV ELECTROCHEMICAL SENSOR



Milestones	Schd	Reschd	a C
 Complete fabrication of prototype VOC and explosives 			
sensors	10/94	70/00	70,00
• Complete initial field toot at first and and a	5	1000	03/34
Semple of mind held test of first generation TNT sensors	10/94	09/94	09/94
 Complete demonstration of improved electrochemical 			
sensor systems	01/96		



TECHNICAL DESCRIPTION



- SCAPS probe prototype that incorporates:
 - External heater to desorb and pyrolyze explosives contaminants in soils
 - Pneumatic system to transport pyrolysis vapors to internal sensors
 - Electrochemical sensor to detect vapors (selective to NO)
 - Signal conditioning electronics
 - Geophysical sensors (sleeve friction and tip resistance)
 - Grouting capability
- Probe collects soil classification data (site stratigraphy) continuously during push
- Probe collects contaminant data during retraction at discrete locations (approx. 1 minute required for each analysis)

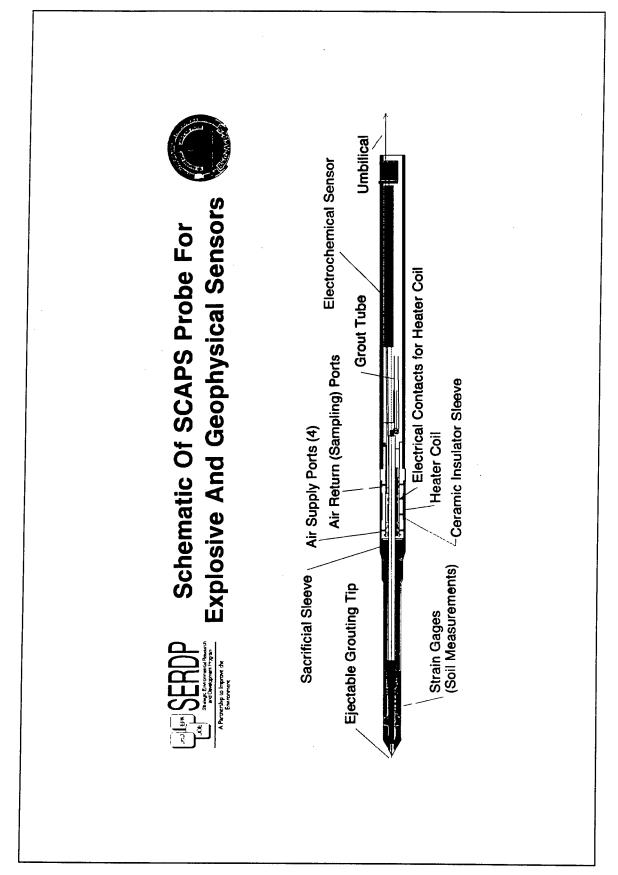


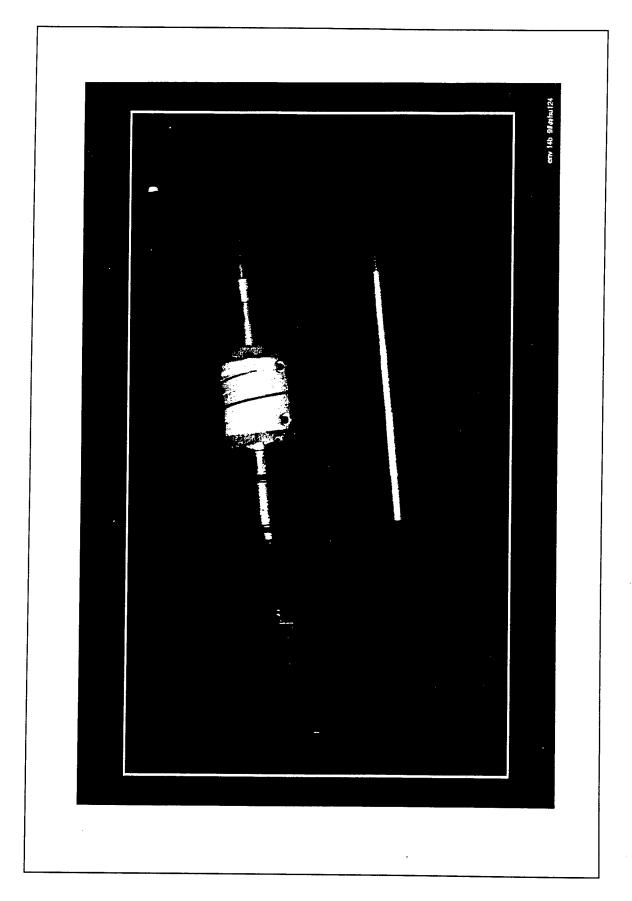
ELECTROCHEMICAL SENSORS FOR SCAPS

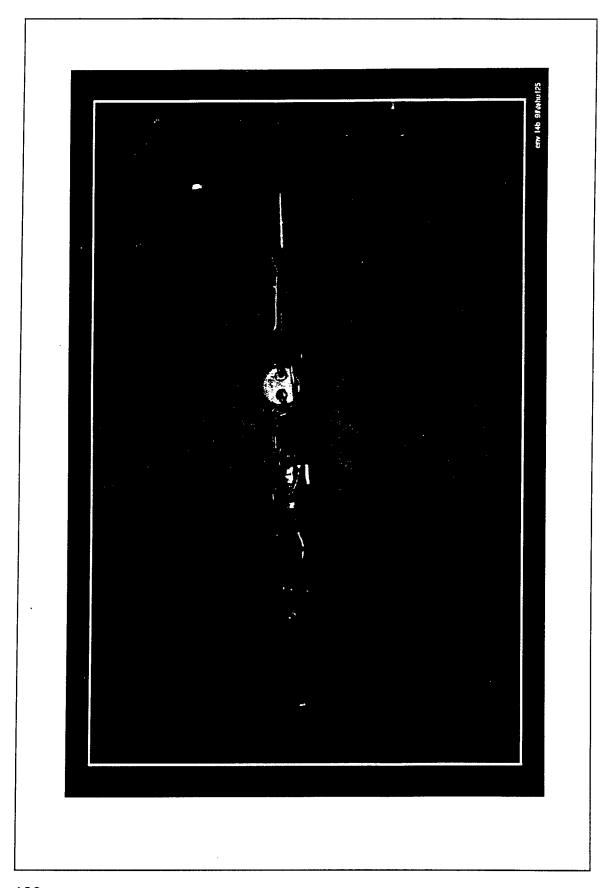


- Low cost
- Small size
- Simple circuit requirements
- Low power requirements
- Powerful analytical properties

$$NO_2$$
 O_2 O_3 O_4 O_2 O_4 O_5 O_5 O_5 O_5 O_6 O_7 O_8 O_8 O_8 O_9 O_9



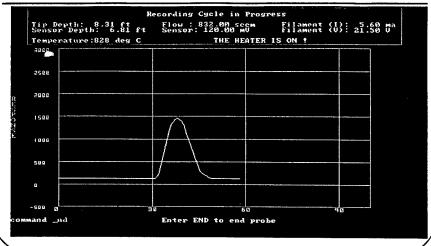






DATA ACQUISITION DISPLAY



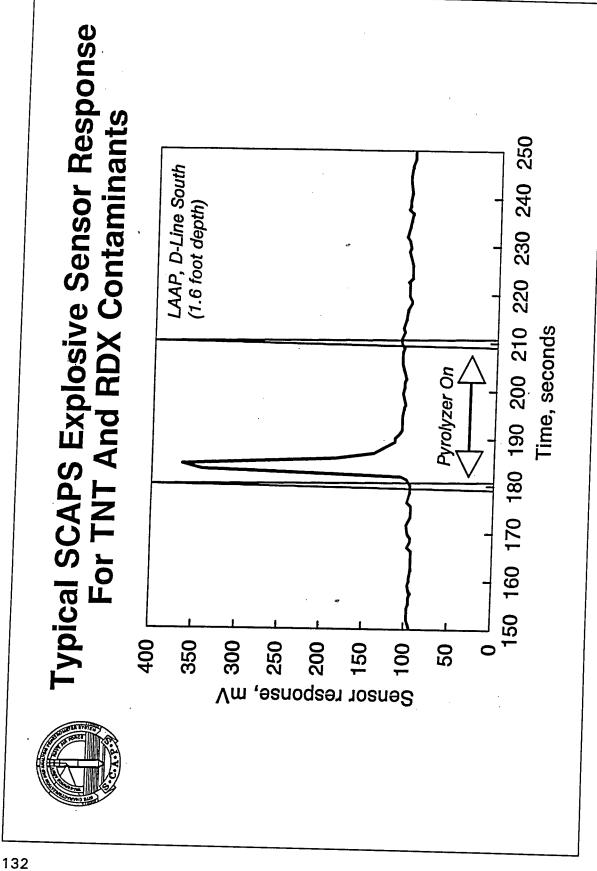


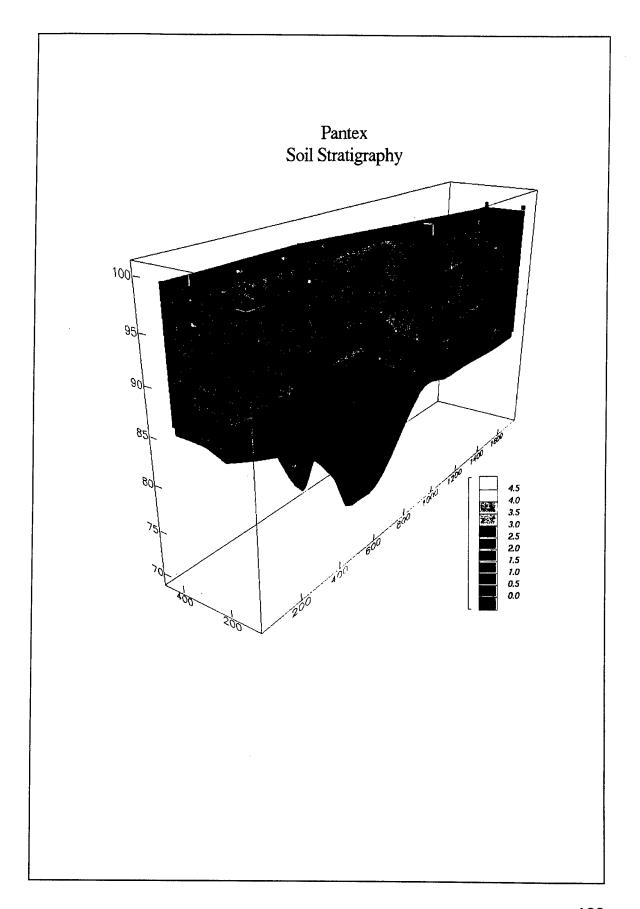


FIELD TESTS



- Louisiana Army Ammunition Plant, LA, 12-16 Sep 1994
 - First prototype tested
- Heterogeneous TNT/RDX contamination
- Wet clay conditions
- Improvements identified
- Pantex, TX (DOE), 6-10 Mar 1995
 - Modified probe tested
 - Dry sand / clay conditions
 - Heterogeneous RDX / HMX contamination
- Volunteer Army Ammunition Plant, TN, 3-7 Apr 1995
 - Improved pneumatic system
 - Improved data acquisition / display system
 - Moist clay conditions
 - Homogeneous (near surface) TNT contamination





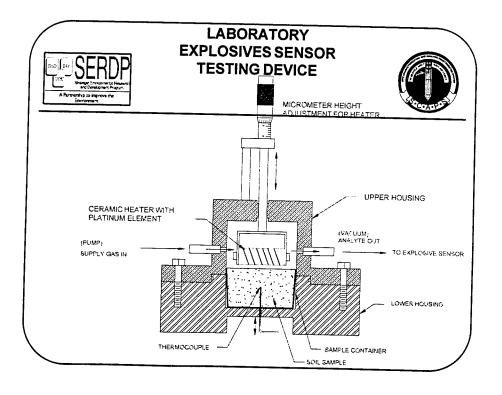


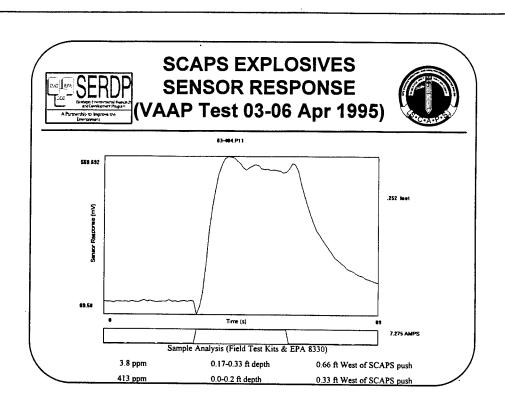
VOLUNTEER ARMY AMMUNITION PLANT TEST 03-06 APRIL 1995

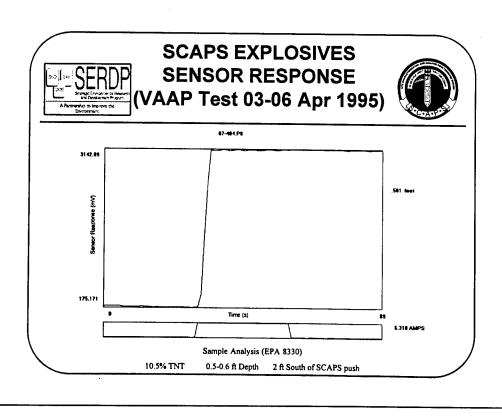


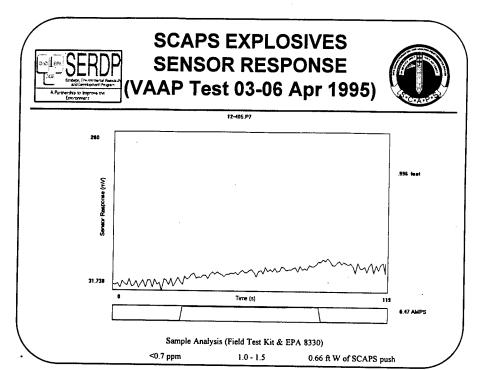
Sample	Location	Depth	SCAPS Sensor	Field Screen	EPA 8330	
Name		(ft BGS)	Response (mV)	TNT (mg/kg)	TNT (mg/kg)	2,4DNT (mg/kg)
SS9	App. 1.5 ft N of 09-405	7.9-8.1	60	<0.7	0.3	<0.25
SS1	App. 3ft E of 06-404	0-0.33	69	0.7	0.4	<0.25
SS6	App. 0.5 ft E of 04-404	0-0.25	156.7	12.1	3.6	<0.25
SS13	App. 0.66ft W of 12-504	0-0.3	363.5	6.8	NP	NP
SS4	App. 0.66 ft S of 03-404	0.17-0.33	488	3.8	NP	NP NP
SS3	App. 0.33ft W of 03-404	0-0.2	590.5		413	
SS10	Between 07&08-404/5	0-0.2	811	89.1	4	2.1
SS11	Between 07&08-404/5	0.25-0.40	1132	756	NP	<0.25
SS12	Between 07&08-404/5	0.5-0.6	SAT.	601	105000	NP 57.5

Note: NP indicates that the sample was not analyzed in the laboratory by EPA method 8330. SAT. indicates that the sensor reached saturation (3142 mV).











EXPLOSIVES SENSOR DEVELOPMENT AND TESTING

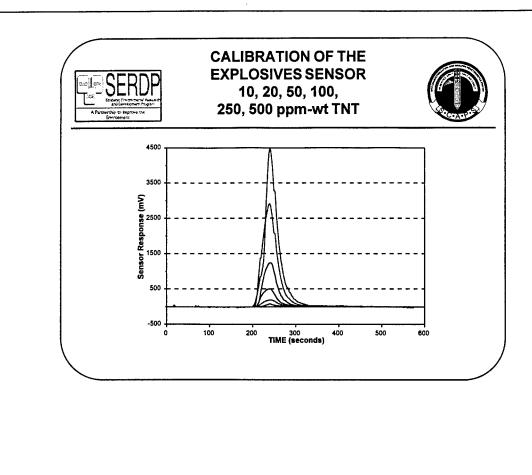


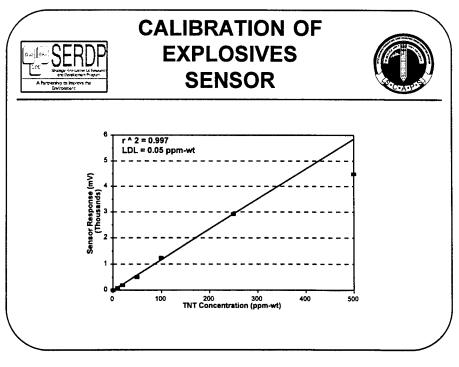
Accomplishments

- Conducted extensive laboratory testing of electrochemical sensors
- Completed three SCAPS field tests at explosives contaminated sites

• Planned

- Complete laboratory characterization of pyrolysis products
- Scheduled to conduct additional field tests at Longhorn Army Ammunition Plant, TX during Sep 95 and Camp Navajo, AZ during Oct 95
- -Field tests / demos at VAAP during 1996









SCAPS ELECTROCHEMICAL VOC SENSOR

William M. Davis

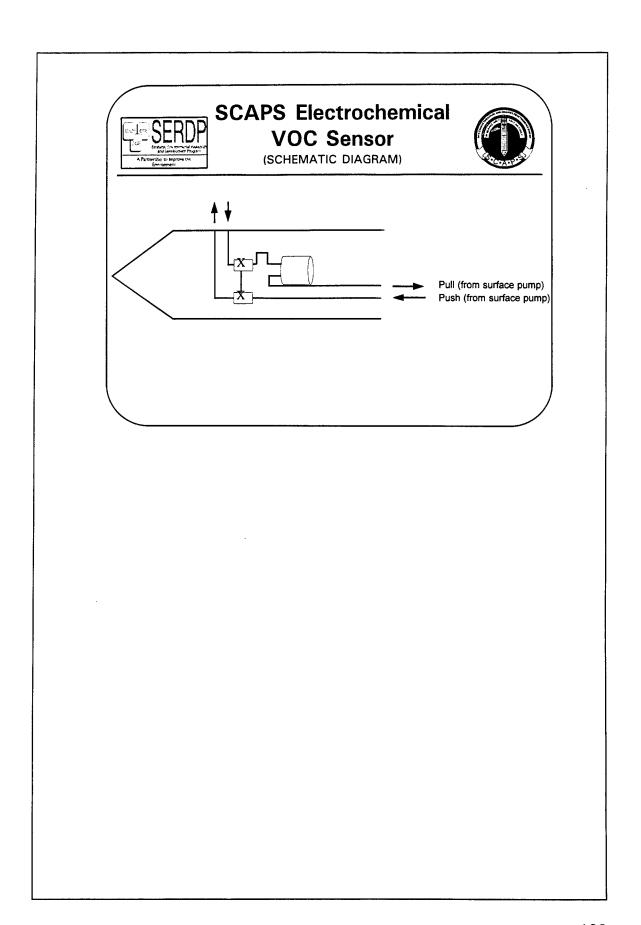
Waterways Experiment Station

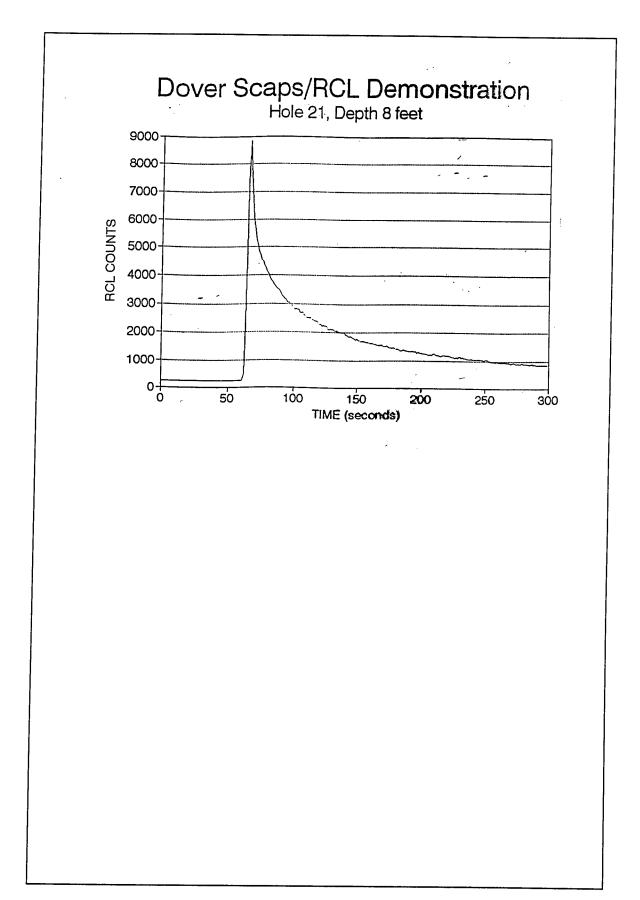


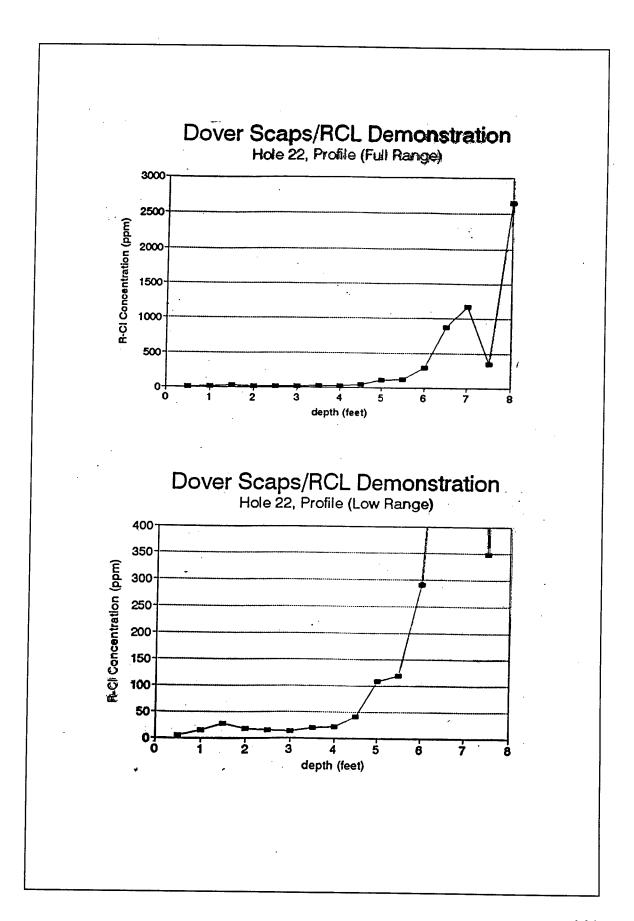
SCAPS Electrochemical VOC Sensor



- Based on Chlorine selective RCI sensor developed by Transducer Research, Inc.
- Plans to incorporate non-chlorinated VOC Sensor
- Soil vapor sensor, deployed in the probe housing designed for the Electrochemical Explosives sensor
- Field tested at Dover AFB, DE in May 1995









SCAPS Electrochemical VOC Sensor



- Successfully field tested the RCI sensor alone
- Modify current probe design to include nonchlorinated VOC sensor
- Perform additional field test



SCAPS Electrochemical VOC Sensor



- Performers:
 - WES: William M. Davis

Ernesto Cespedes

- TRI: William Buttner

Mel Findley



RESEARCH AREA V SPECTRAL GAMMA PROBE



Milestones

Complete improved SCAPS spectral gamma probe

03/95 10/95

Reschd

Complete field testing / demonstration of improved gamma probe

02/96

Schd



Spectral Gamma Probe Participants

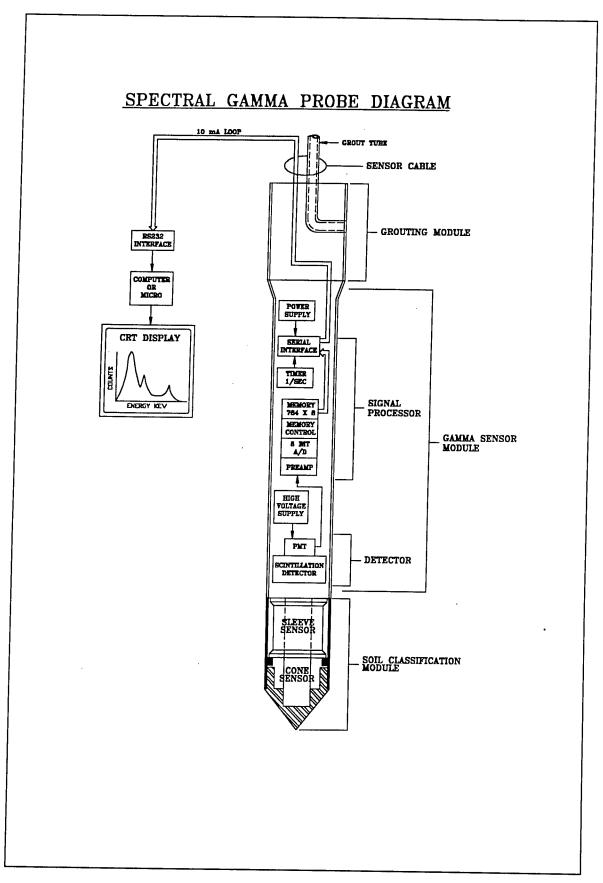


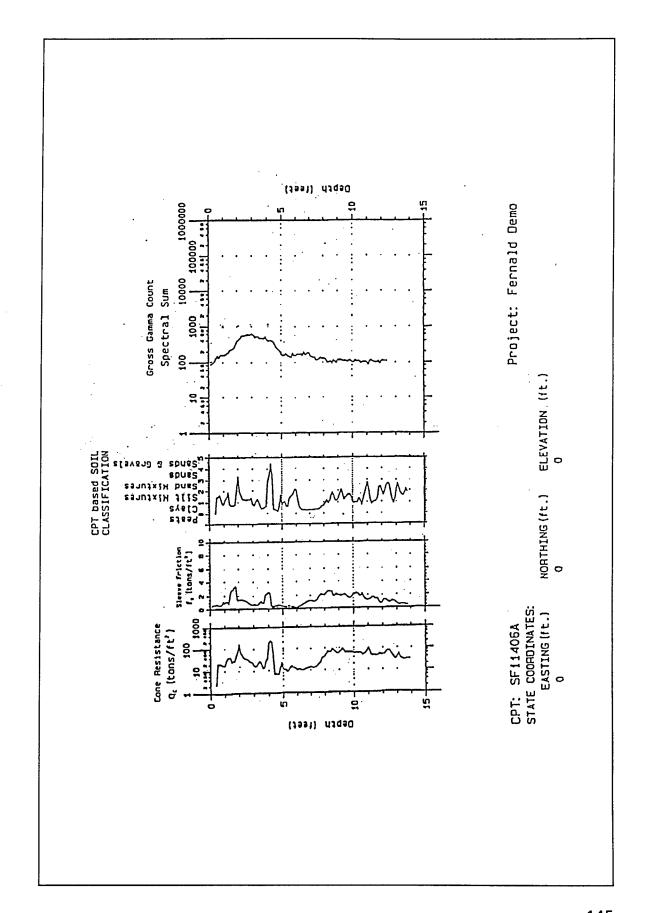
Principal Investigator: Ernesto R. Cespedes

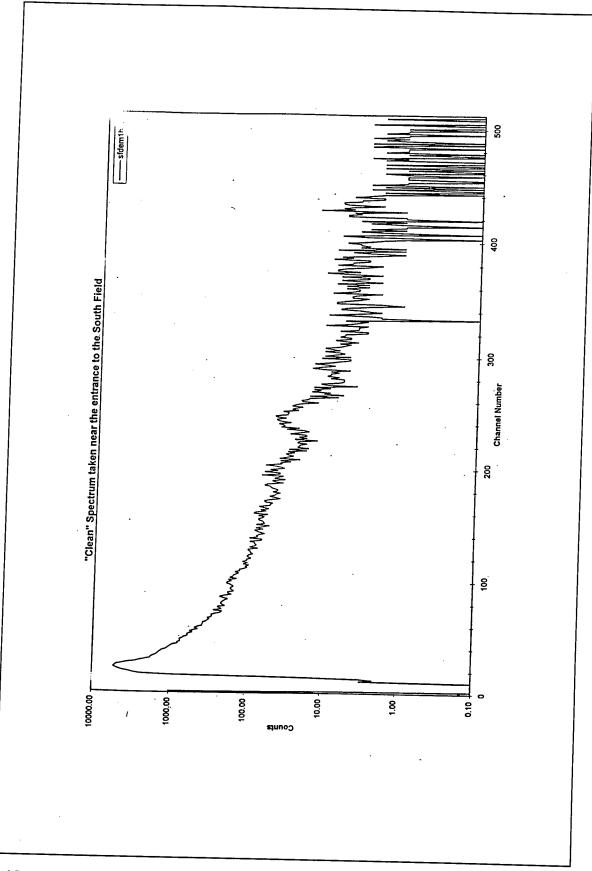
Physicist: Bobby E. Reed

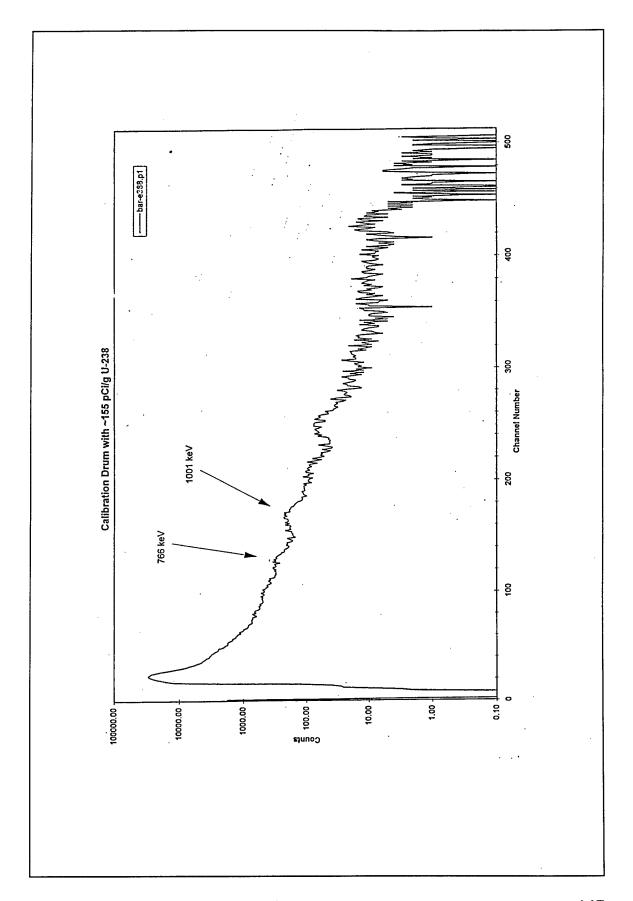
Electrical Engineer: Bryan A. Register

Physicist: John C. Morgan











Spectral Gamma Probe Problems Encountered



Temperature Stability

Analysis Difficulty

Housing Attenuation

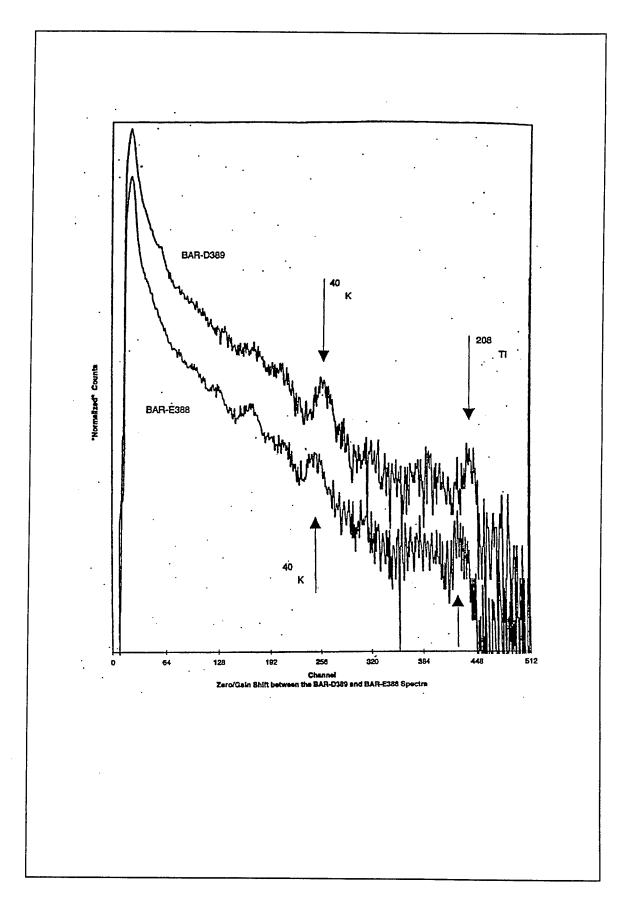


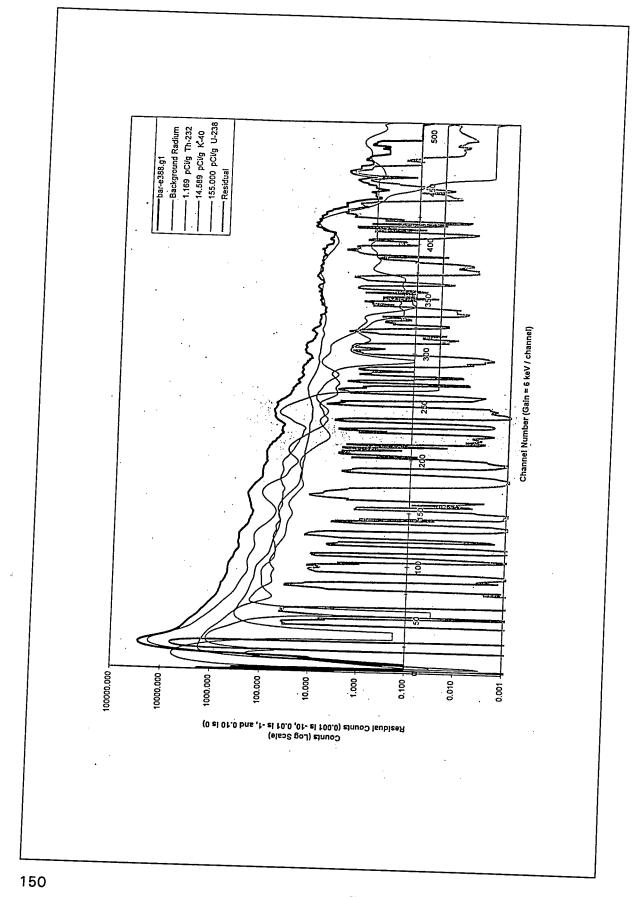
Spectral Gamma Probe Analysis Difficulties Encountered



High Thorium Background

Gain Shifts







Spectral Gamma Probe Improvements



Standard Electronics

Custom electronics have been replaced with modular NIM rack mounted industry standards

· Improved Data Storage

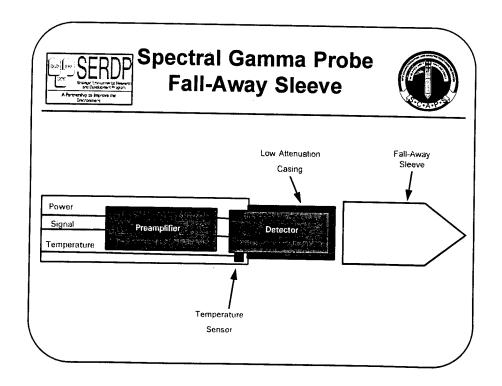
- Data is stored in small blocks allowing post processing methods

• Temperature Correction Algorithms

 Gain shift and offset problems from temperature sensitive components can be corrected in post processing

· Fall-away Sleeve

 Allows low energy portions of the spectrum to be observed, and reduces noise from scattered photons



RESEARCH AREA VI SAMPLING TECHNOLOGY





Milestones	Schd	Reschd	Comp
· Complete initial testing of thermal desorption VOC sampler	05/95		05/95
· Complete field evaluations of multiport VOC sampler	06/95		05/95
· Complete laboratory testing of analyte behavior in soils	96/80		
· Complete field tests of thermal desorption VOC sampler			
interfaced to analytical instr	10/96		
Complete description of analyte behavior in soils	12/96		
Complete evaluation of quantitative aspects of SCAPS			
samplers	12/96		





ANALYTE BEHAVIOR IN REGION OF SAMPLER



PROBLEM



 THE RELATIONSHIP BETWEEN SOIL CONTAMINANT CONCENTRATION AND THE CONCENTRATION MEASURED BY THE SAMPLER ARE UNKNOWN



APPROACH



- DEVELOP COMPUTATIONAL PROCEDURES
 VAPOR DRAWDOWN AND CONE OF INFLUENCE
- LABORATORY EVALUATION
 MIGRATION TO SAMPLING PORT
 GRADIENT CAUSED BY SAMPLING
 ACCURACY OF MEASUREMENT
- EVALUATE PROCEDURES DEVELOPED USING FIELD DATA



BENEFIT



MOVE FROM SCREEN TO SEMI-QUANTITATIVE WITH VAPOR SAMPLING DEVICES

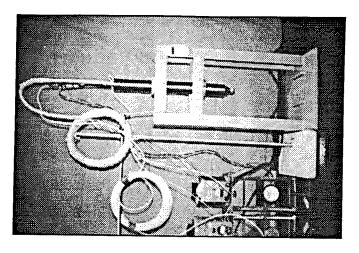


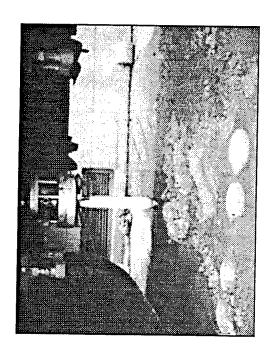
IMPROVED VOC SAMPLER



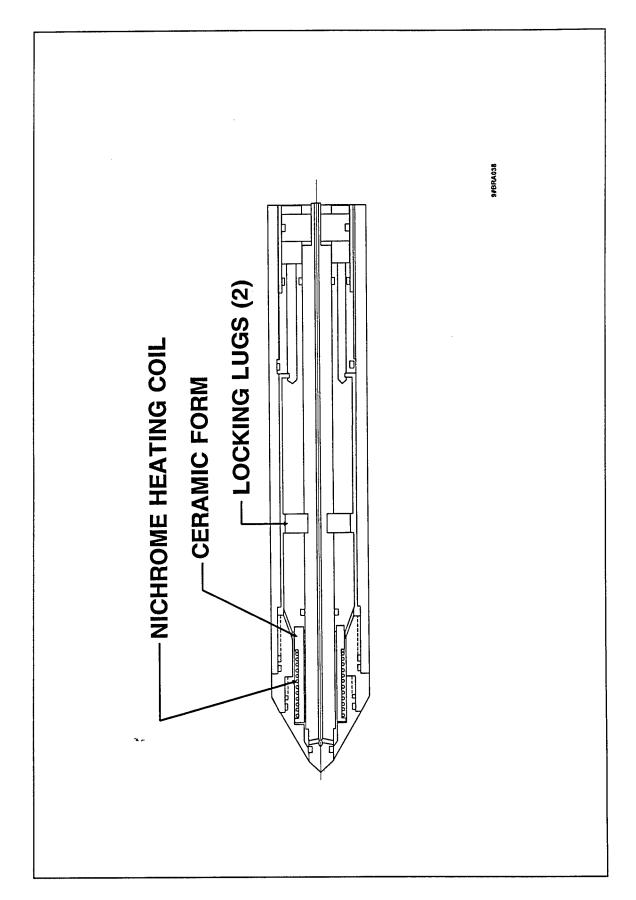
US ARMY ENGINEER WATERWAYS EXPERIMENT STATION
3909 HALLS FERRY ROAD
VICKSBURG, MS 39180-6199

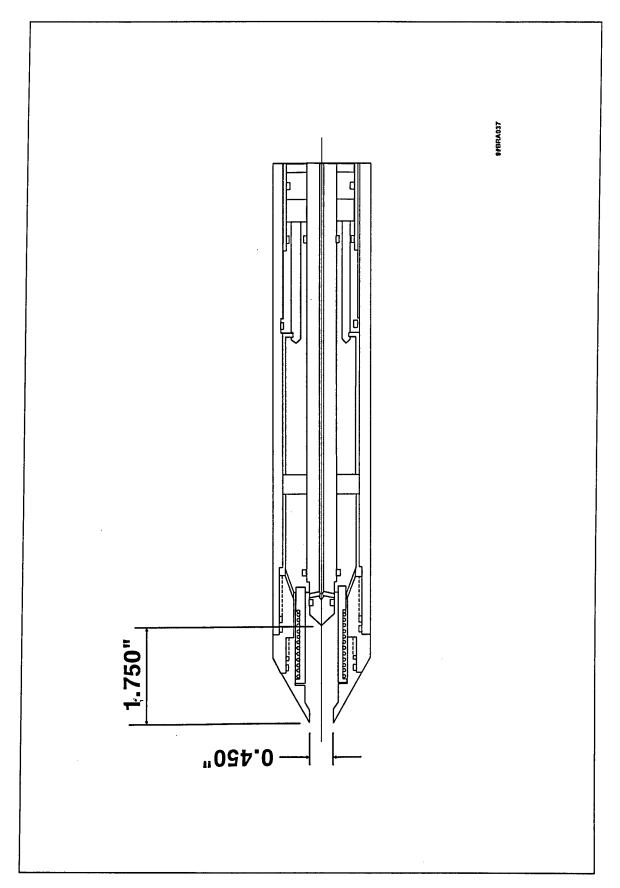
Thermal Desorption VOC Sampler





env 15/b 9#/#H113







IMPROVEMENTS



- EXPANDED SUITE OF COMPOUNDS
- SOIL VAPOR SAMPLING
- MECHANICAL SIMPLICITY
- IMPROVED GAS MANIFOLD
- DIRECT ANALYTICAL INTERFACE



APPROACH



- EXTENDED RANGE OF COMPOUNDS AND PROVIDE FOR DIRECT INSTRUMENT INTERFACE
- EVALUATION OF IMPROVED SAMPLER
- FIELD TEST IN SOIL AND VAPOR SAMPLING MODES
- INTERFACE TO ANALYTICAL INSTRUMENTATION
- FIELD TEST VOC SAMPLER INTERFACED TO ANALYTICAL INSTRUMENTATION



ORIGINAL TARGET COMPOUNDS



trans-1,2-Dichloroethene

Trichloroethene (TCE)

Benzene

Toluene

Chlorobenzene

Ethylbenzene

meta-Xylene

para-Xylene

ortho-Xylene

meta-Dichlorobenzene

para-Dichlorobenzene

ortho-Dichlorobenzene



ADDED COMPOUNDS



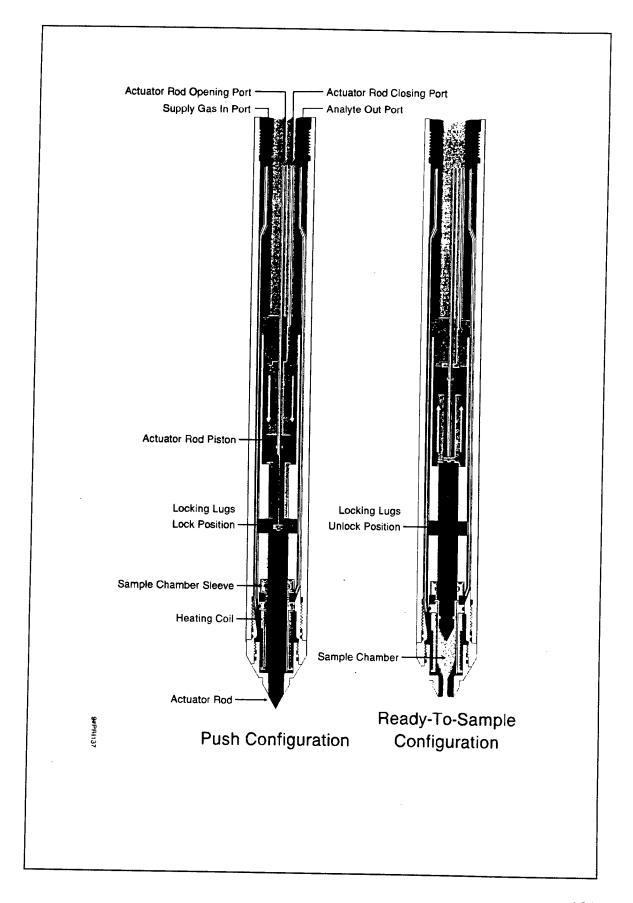
1,1-Dichloroethene

cis-1,2-Dichloroethene

Tetrachloroethene (PCE)

Naphthalene

2-Methylnaphthalene





BENEFITS



- INCREASED NUMBER OF COMPOUNDS
- INCREASE SPEED OF ANALYSIS
- INCREASED VERSATILITY



MILESTONES



- 08/96: COMPLETE LABORATORY TESTING OF ANALYTE BEHAVIOR IN SOILS
- 10/96: COMPLETE DESCRIPTION OF ANALYTE BEHAVIOR IN SOILS





Lead Organization:

U.S. Army Environmental Center Aberdeen Proving Grounds, MD 21010-5401

Mr. George E. Robitaille SFIM-AEC-ETP Voice: 410-612-6865 FAX: 410-612-6836

Poc

A Partnership to Improve the Environment



TECHNICAL DESCRIPTION



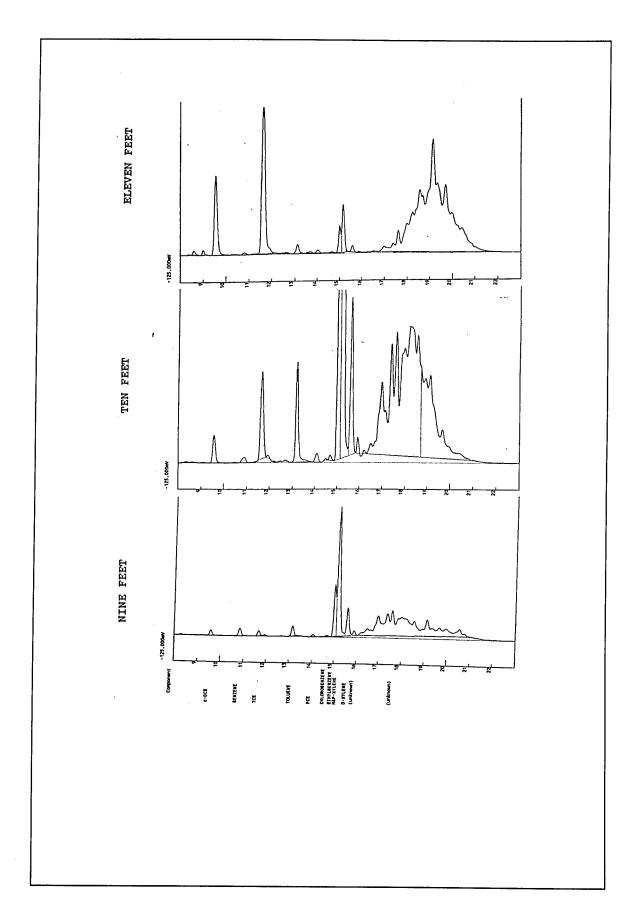
- In-Situ Thermal Desorption of Soil VOC's
- Field Analysis of VOC's
 - Simple VOC Detectors
 - Gas Chromatograph or Ion-Trap
 - Mass Spectrophotometry
- Vadose Zone and Saturated Zone Sampling
- Vapor Sampling in Vadose Zone

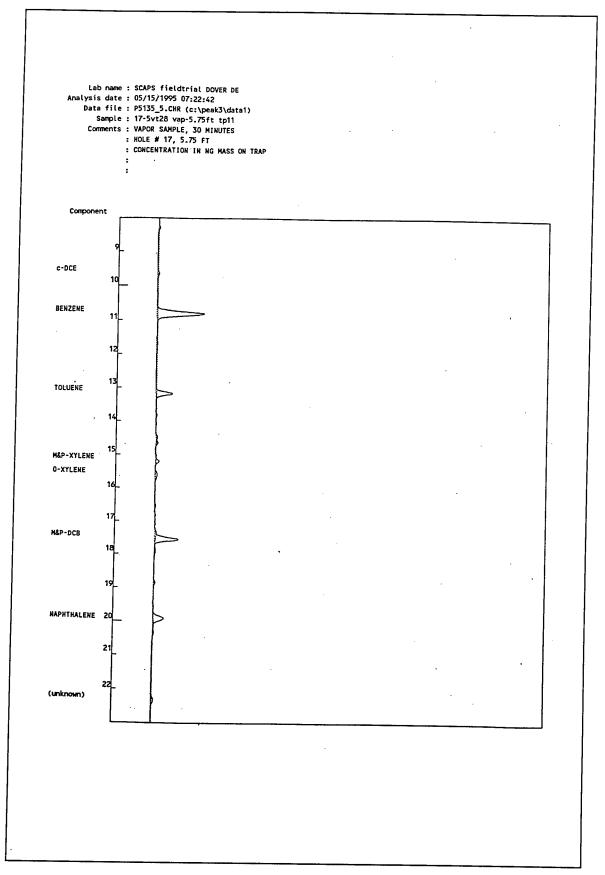


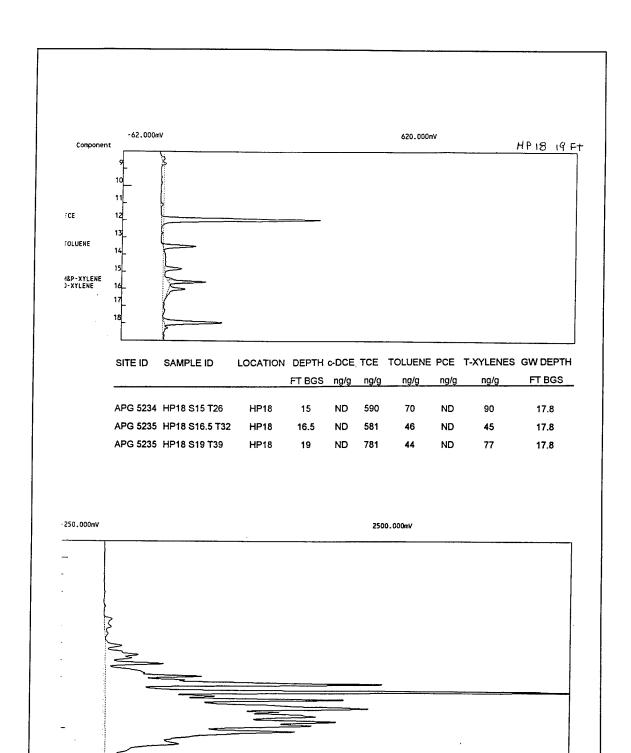
VERIFICATION



- Laboratory Analysis of Verification Soil Samples
- Compare with VOC Analysis System Results



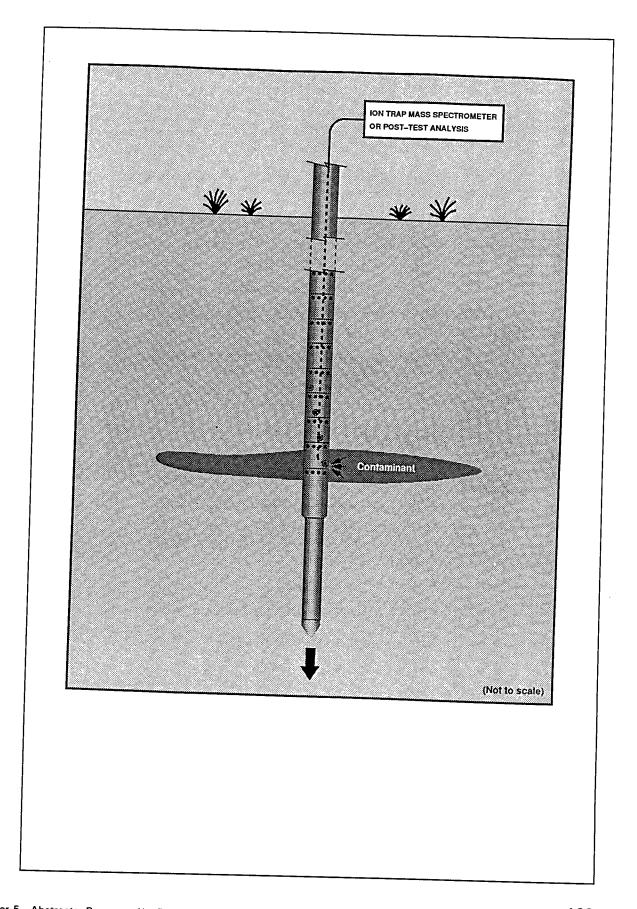




THE MULTIPORT SAMPLER

OBJECTIVES

- Improve operational capabilities of Multiport Sampler
- Field Test the Multiport Sampler
- Model behavior of analyte in region of sampling port (In preparation of laboratory investigation)



ACCOMPLISHMENTS

- Paper for ASTM Special Technical Publication 1282 entitled, "The Multiport Sampler: An Innovative Sampling Technology."
- WES Technical Report entitled, "Design, Development, and Operation of the Multiport Sampler."
- Modified the MPS to improve its' operational capabilities:
 - a) Eliminated the twelve screw attachment design (three dowel pins have replaced the screws).
 - b) Fabricated new modules, ports, pistons, and adapters.
 - c) Developed procedure for measuring volume drawn through the Contaminant Trap.
 - d) Modified control panel to allow detection of port leakage.
 - e) Fabricated two cone mandrels.

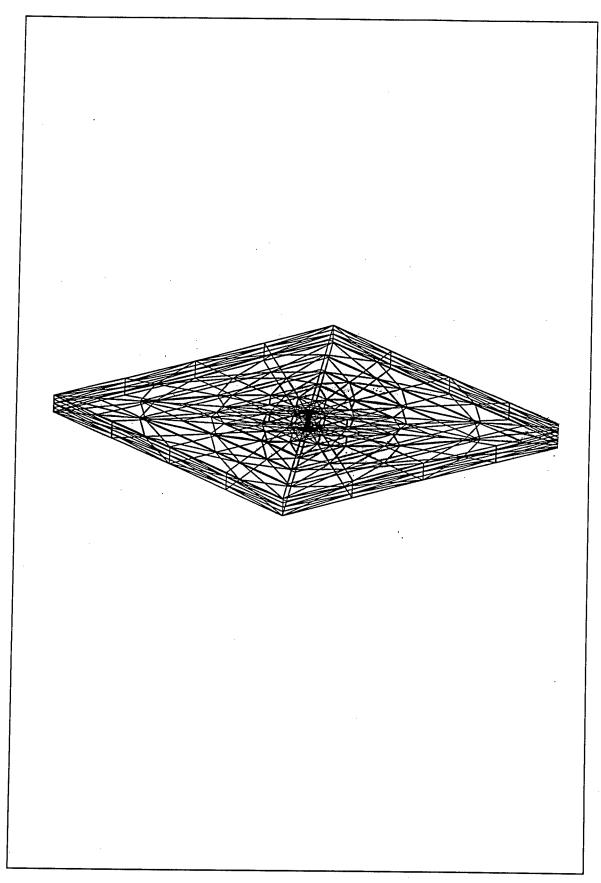
ACCOMPLISHMENTS (Cont'd)

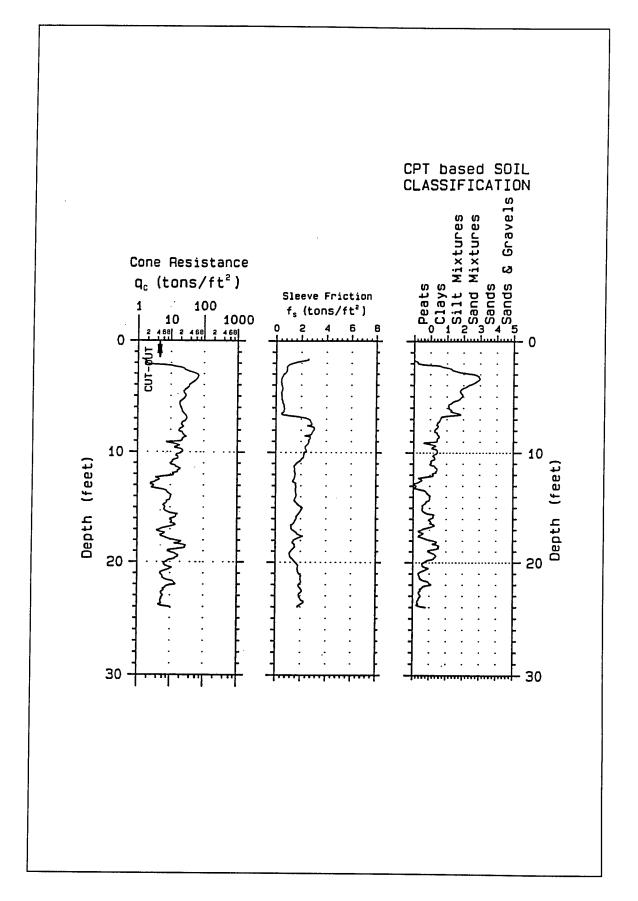
- · Field test at Dover AFB, Delaware.
- Initiated numerical analysis of analyte behavior in region surrounding sampling port.

FIELD TEST DOVER AFB, DELAWARE 1-5 MAY 95

Multiport Sampler Direct Measurement and Contaminant Trap Field Data Taken at Dover AFB, Delaware

Hole Hole	<u>Data Type</u>	<u>Depth</u>	<u>1.1.1-TCA</u>	TCE	<u>Benzene</u>	<u>Toluene</u>
DVRMPS1	CT	7.83	5990	1351	0	o
DVRMPS1	DM	8.00	12910	206	0	0
DVRMPS1	DM	9.00	11640	109	0	0
DVRMPS3	СТ	4.83	423	0	0	35
DVRMPS3	DM	5.00	546	0	14	23
DVRMPS4	СТ	5.83	1537	0	274	66
DVRMPS4	DM	6.00	3063	0	6	28
DVRMPS7	DM	7.00	166350	4560	0	0
DVRMPS7	DM	8.00	86770	2382	0	0
DVRMPS8	DT	7.0-9.0	1000-1250	0	N/A	N/A
DVRMPS8	CT(C-18)	21.5	1	0	0	9/





NUMERICAL MODELING OF ANALYTE IN REGION OF SAMPLING PORT

Modeling Parameters

- · Permeability of moist sand to air
- · Mass transfer rate of TCE from water to air
- · Compressibility of air
- Maximum concentration of TCE in water
- · Molecular diffusion of TCE in air
- · Dispersivity (relative to flow direction)
- Effective porosity
- · Maximum concentration of TCE in air
- Mesh dimensions



RESEARCH AREA VII DATA PROCESSING METHODOLOGIES



2	Milestones	Schd	Reschd Comp	Comp
•	 Complete development of data processing methodology 	10/94	10/94 11/94 11/94	11/94
•	Complete development of enhanced data acquisition,			
	analysis, and visualization software	96/20		
•	 Complete testing and user review of enhanced software 	96/90		



SCAPS DATA PROCESSING FRAMEWORK



Objective

 To develop acquisition, analysis, and visualization software to exploit the capabilities of emerging sensor and sampler technology

Software Components

- -Acquisition and real-time display
- Processing, analysis, and database management
- -3D visualization



SCAPS DATA PROCESSING FRAMEWORK



• Hardware Architecture

- -Acquisition MS-DOS PC
- Processing/Visualization Unix workstation with 24-bit z-buffered graphics (may be ported to PC in the future)

Approach

 Develop a flexible software architecture that incorporates a graphical user interface and a well-defined database structure to facilitate incorporation of new sensors



SCAPS DATA PROCESSING FRAMEWORK



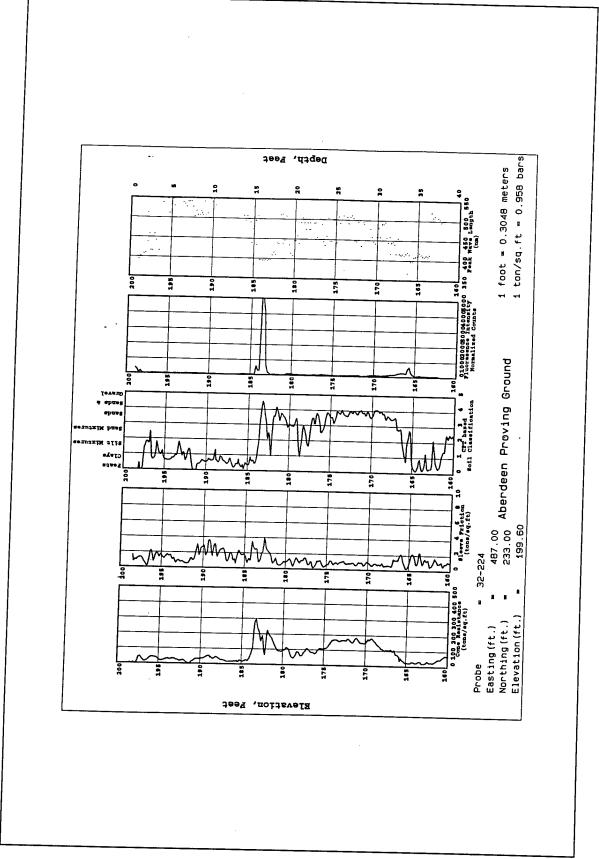
- Approach (cont.)
 - Continue development of the SCIRT (MSU) 3D visualization software
 - Maintain links to Earthvision (DGI) software
 - Incorporate new sensors
 - Develop capability for storage/retrieval of SCAPS database on CD-ROM
 - Investigate porting processing/visualization software to PC

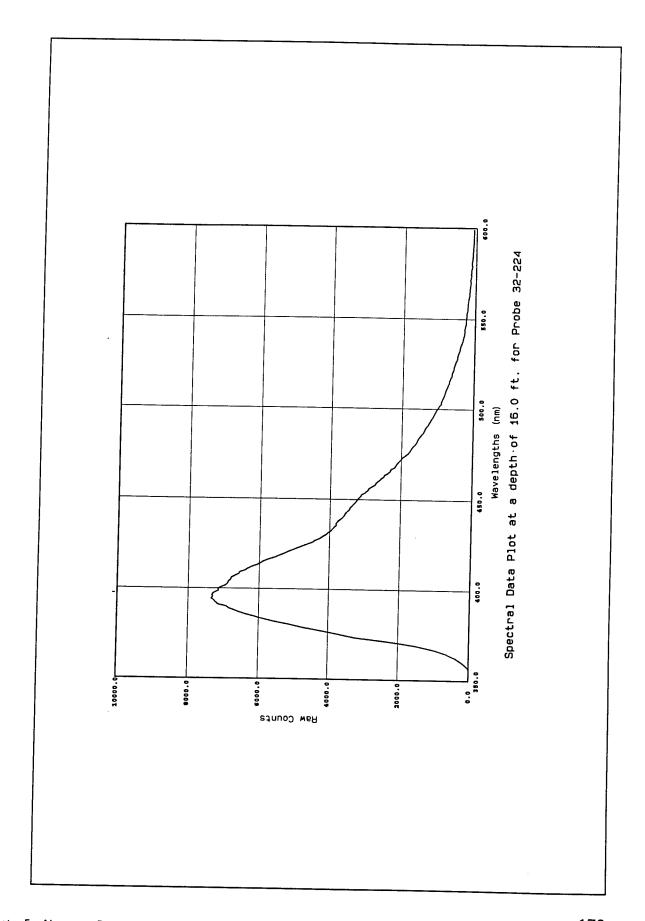


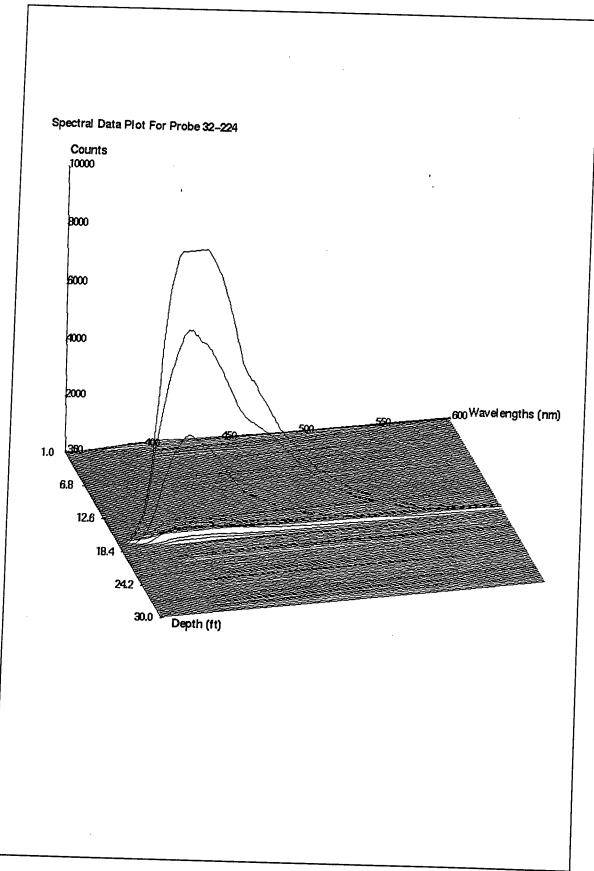
ACCOMPLISHMENTS

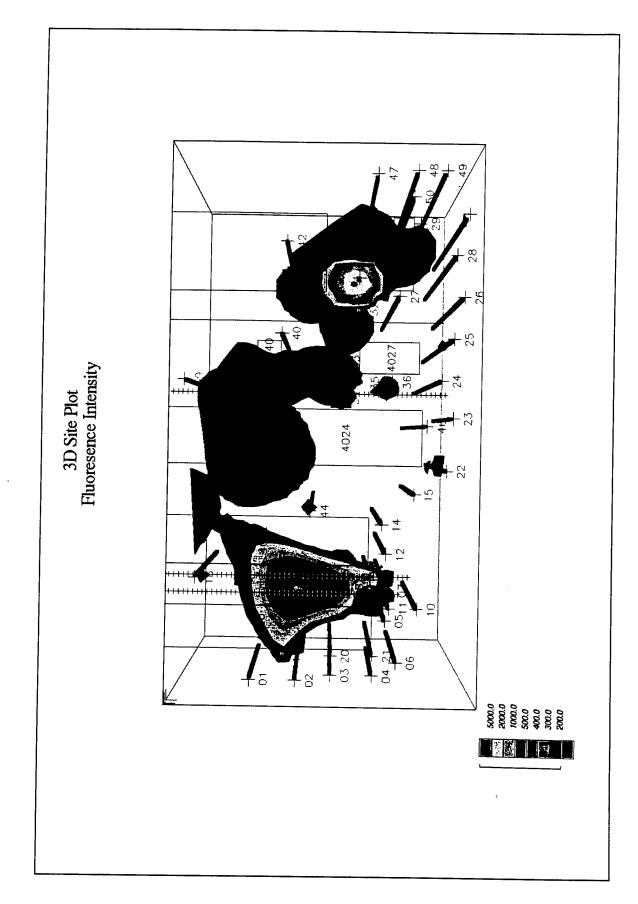


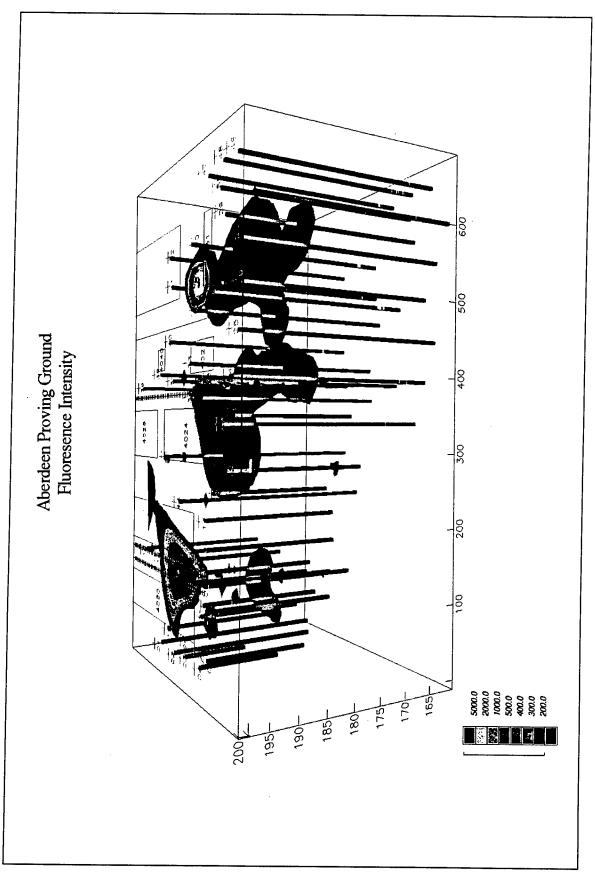
- Completed initial version of software that incorporates a graphical user interface and database structure and provides an interface to SCIRT and Earthvision
- Demonstrated 3D visualization in the field
- Modifications to SCIRT
 - Improve interpolation algorithms
 - Display a site map on 3D plume
 - Conversion to open GL













ACCOMPLISHMENTS



- Completed software to acquire and display data from explosives probe
- Procured and tested a CD-R system
- Investigated issues related to porting processing/visualization software to a PC



FUTURE WORK



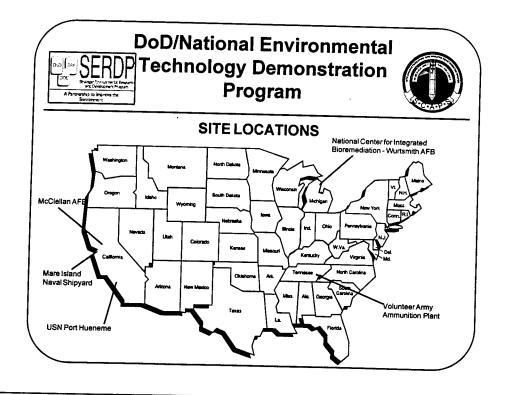
- Complete SCIRT modifications and test
- Incorporate new sensors
- Make improvements to acquisition, processing, and database management software
- Evaluate the use of the groundwater modeling system (GMS) for SCAPS
- Documentation
- Port software to Windows NT-based PC



Technology Demonstration Implementation



- OBJECTIVE: To demonstrate SCAPS sensors, sampling hardware, and associated data processing technologies
- APPROACH: Conduct demonstrations with SCAPS, comparing SCAPS data with data obtained through traditional sampling and analysis methods





Use of DoD NETDP Test Sites



- Groundwater Remediation Field Laboratory National Test Site (Dover AFB, DE) - LIF, VOC Probes
- Natural Attenuation Test Site (Columbia AFB, MS) LIF
- Port Hueneme, CA LIF
- Wurtsmith AFB, MI LIF
- Volunteer Army Ammunition Plant Explosives Sensors
- McClellan AFB, CA LIF
- Others TDB



Field Testing & Demonstrations



	Comp.
EPA SITE Demonstration of LIF POL Sensor	09/94
 Initial Field Testing of Explosives Sensor (LAAP) 	10/94
 Field Testing of Explosives Sensor (Pantex) 	03/95
 Field Testing / Demonstration of Explosives Sensor (VAAP) 	04/95



Field Testing & Demonstrations



	Schd.
Conduct Columbus AFB Demonstration of POL Sensor	05/95 /
 Conduct Dover AFB Demonstration 	05/95
 Complete Initial Field Evaluation of Thermal Desorption VOC Sampler 	30/30
	05/95
 Conduct Port Hueneme, CA Demonstration 	06/95
 Conduct Wurtsmith AFB, MI Demonstration 	07/95
 Conduct Field Test of Explosives Sensor (Camp Navajo, AZ 	
 Complete Field Demonstration of Improved Multiport Sample 	er 10/95
(Continued)	12,00



Field Testing & Demonstrations



	Schd.
 Conduct Demonstration of SCAPS Electrochemical Probes with Associated Software 	01/96
Conduct Validated and Demonstrated Enhanced SCAPS LIF POL Sensor and Software	
	03/96
 Initiate Field Testing / Demonstrations of FORS System 	04/96
Complete Demonstrations of Improved Sampler Technologies	10/96
Conduct Demonstrations of LIBS Sensor System	12/96
Complete Demonstrations of FORS System	01/97
Conduct Demonstration of PF / LIF Explosives Sensor System	06/97



TRANSITION PLAN



- R&D results will be documented in peer-reviewed journals, technical conference proceedings, and agency technical reports
- Yearly meetings of peer review panel, researchers, developers, and users will be conducted, and proceedings published
- Field demonstrations will be conducted and results will be documented in technical reports
- Validated sensors and supporting SCAPS technologies will be made available to Government SCAPS users, complete with documentation, O&M manuals, and onsite training
- Tri-Services will continue to aggressively pursue commercialization of SCAPS technology through licensing agreement, CRADA's, and TRP



EXPECTED PAYOFF



- Provide rapid, cost effective methods to characterize sites
- Significantly increase the number and types of contaminated sites that can be characterized by SCAPS
- Maximize cost savings by accelerating the fielding of new SCAPS technologies to support remediation efforts
- Increase acceptance of SCAPS as a rapid field screening tool by users, regulators, and public

Technology Demonstration/Implementation

Objective: Demonstrate SCAPS Sensors, Specifically Tunable LIF (ROST), Sampling Hardware, and Associated Data Processing Technologies With Respect to Jet Fuels and Gasolines Having Lighter Aromatic Compounds (BTEX).

Approach: Conduct SCAPS Demonstrations With Tunable LIF System, Comparing Data to that Obtained Through Traditional Sampling and Analyses Methods.

Payoff: Validation of SCAPS Performance and Cost Effectiveness for Site Characterization From a Users Perspective (KC CoE) and to Facilitate User and Regulatory Acceptance.

Technology Demonstration/Implementation Status

Making Use Of Kansas City CoE SCAPS

- Transitioned Laser Sep 94
- Subcontract to DTI for Tunable Laser Support May 95
- Hardware Upgrade May 95
- Integrate Tunable Laser June 95
- Provide Training, Including on the Job May/June 95

Wurtsmith AFB National Test Site Demonstration Completed

- Firefighter Training Area Site Having Mixture of Contaminants
- Innovative Hollow Stem Auger/Split Barrel Sampler
 Ensures What is Sensed is Sampled!
- Sample Analyses and Chemical Data Analysis Ongoing

Dover AFB National Test Site Demonstration Initiated

- Hydrant Fuel System Contamination Believed to be Just JP-4
- Site Also Has Sands/Gravels With Shallow Groundwater

Technology Demonstration/Implementation Status (cont.)

Columbus AFB, MS

- SERDP Funded Natural Attenuation Test Site (NATS)
- Primarily Sands/Gravels and No Contamination Until Release
- Demonstration Cancelled Due to Delayed Site Approvals

Port Hueneme, CA

- Also Primarily Sands
- Not Selected Due to Excellent Navy Sponsored Demonstration
 Made Use of ROST System on Navy SCAPS

Site Needs

- Emphasize Demos at Sites Having Only Jet Fuel or Gasoline
 Laser Wavelength at 290nm or Lower
- Heterogenety in Vadose Zone, Especially Fine Grained Soils
 Sampling Below Water Table is Problematic

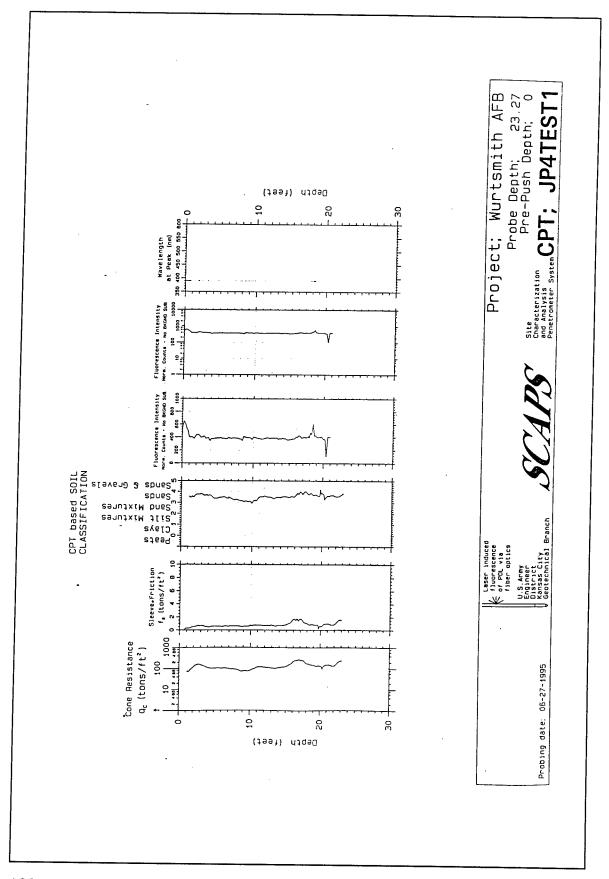
Technology Demonstration/Implementation Status (cont.)

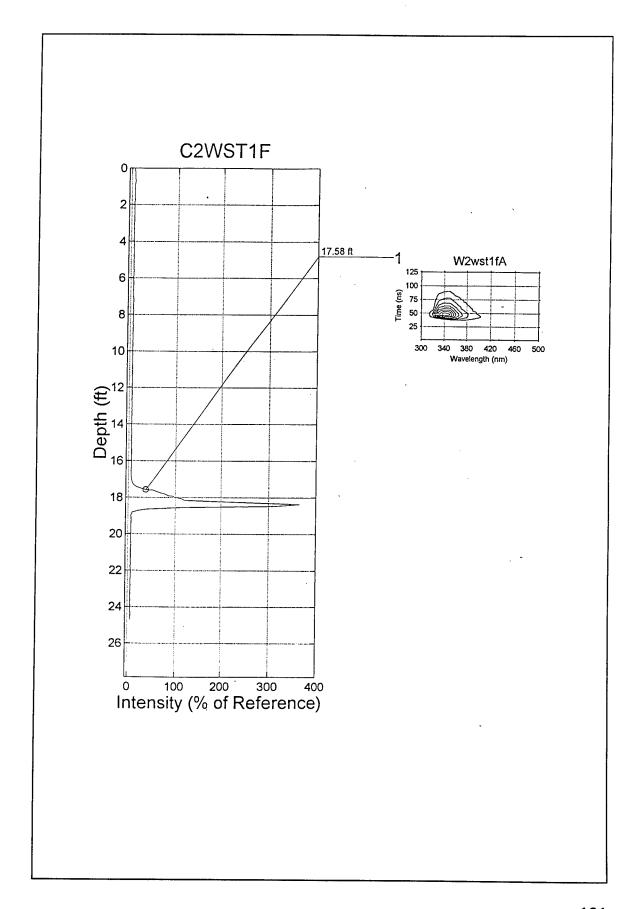
Propose Eaker AFB, AR as Demonstration Site

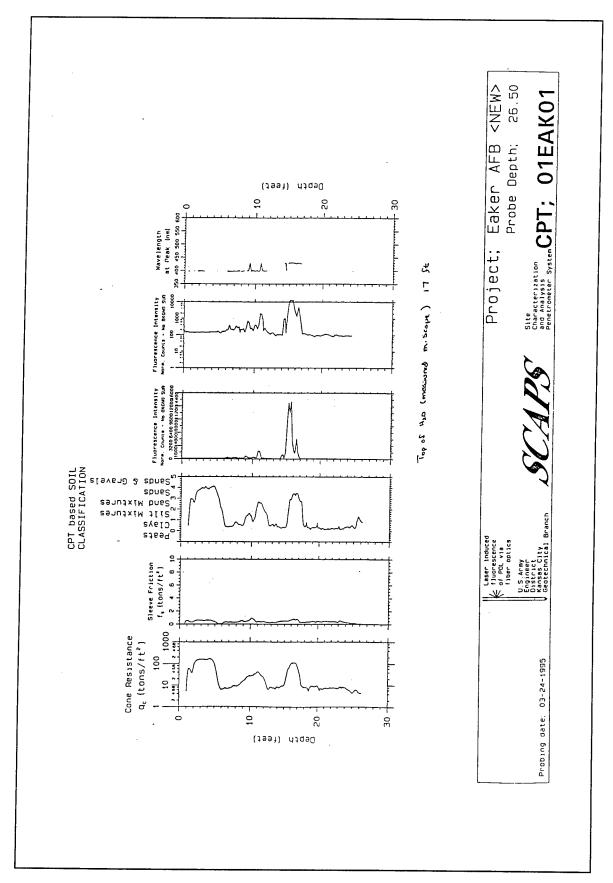
- Excellent Data Set From AFCEE SCAPS Project
 - -Used N, Laser
- Gasoline Contamination (Dover Provide JP-4 Site)
- Heterogeneous Soils
 - ∸From Fine Grained (Silt/Clays) to Sands
- Contamination in Vadose Zone Above Water Table

Project Schedule

- National Test Sites
 - -Wurtsmith AFB, MI Jun/Jul 95
 - -Dover AFB, DE Jul/Aug 95
- Eaker AFB, AR Sep 95
- Complete Laboratory Analyses & Reporting Sep 95
- Complete Draft Report Delivered Oct 95
- Project Outbrief To Armstrong Lab & Tri-Services Nov 95
- Final Technical Report and Project Completion 31 Dec 95









IMPLEMENTATION: NAVY SCAPS-LIF PROGRAM



- JUNE 1993 HQ/NAVFAC INITIATED PROGRAM
- PROGRAM ELEMENTS (TRI-SERVICE COORDINATED)
- ► EXPEDITED DUAL-USE OF R&D SYSTEM (EDM-1)
- SITE WORK (NAVY)
- · REGULATORY ACCEPTANCE (TRI-SERVICES)
- EXPEDITED TECH TRANSFER
- · LIMITED NAVY ACQUISITION (2 EDMs)
- · COMMERCIALIZATION (CRADA, ET AL)
- ▶ PRE-PLANNED PRODUCT IMPROVEMENTS
- UPGRADED SYSTEMS/PROCESSES
- **NEW SENSORS**

.

TRC TSRG SCAPS-LIF Brief



EXPEDITED DUAL-USE OF RESEARCH SYSTEM NAVY PROGRAM ELEMENTS:



NAVY SITE WORK

HIGH PRIORITY IR SITES WITH DISTINCT SCAPS-LIF VARIABLES

► 14 SITES

* *Products*: Known/Unknown Pols-Fresh/aged, Seperate/Mixed, above/below water

SOILS: CLAYS-SANDS-COBBLES, LAYERED MATRICES, DRY-VADOSE-SATIURATED ZONES

• SITES: COASTAL/DESERT, URBAN/REMOTE, SHALLOW/DEEP WATER

* *REGULATORS*: LOCAL, STATE, REGIONAL, FEDERAL

EXAMPLES: 100 YR OLD REFINERY, ACTIVE/INACTIVE FUEL FARMS, ABANDONED OIL FIELD, FIRE FIGHTER FRAINING SITES, GAS STATIONS, USTS

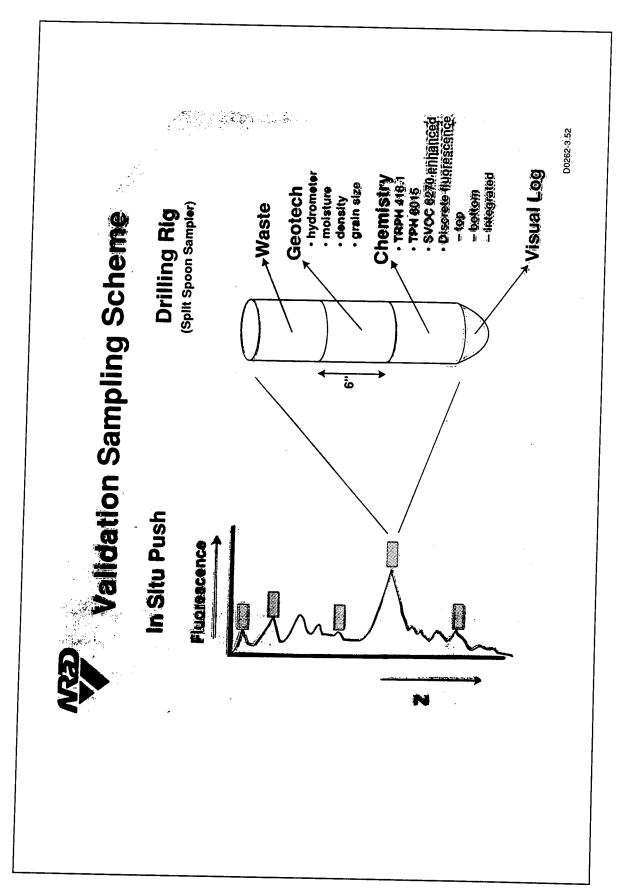


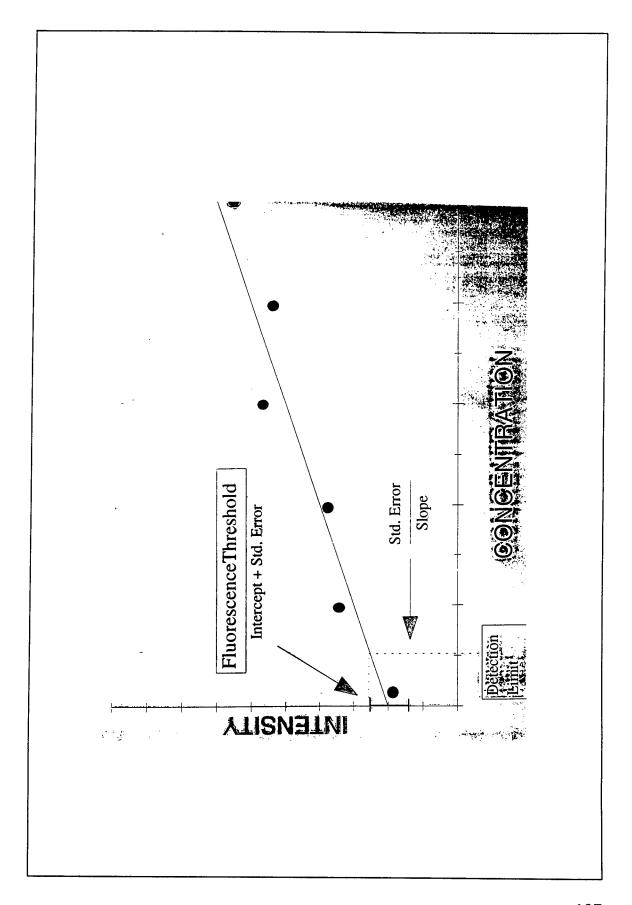
EXPEDITED DUAL-USE OF RESEARCH SYSTEM NAVY PROGRAM ELEMENTS:



(CONTINUED)

- TRI-SERVICE REGULATORY ACCEPTANCE
- ESTABLISH HIGH QUALITY VALIDATION DATABASE CONCURRENT WITH FIELD OPS
 - VSE/COMPARE TRADITIONAL VS SCAPS-LIF
 - WORK CLOSELY WITH REGULATORS
- ► LIF DEMOSTHREE INTERLINKED PROGRAMS
 - CAL EPA "CERT" PROGRAM (STATE)
- WGA/DOIT DEMONSTRATION (REGIONAL)
- US EPA CONSORTIUM DEMONSTRATION (NATIONAL)
 - ► EAST COAST REGULATORY ACCEPTANCE
- * REPLICATE/EXTEND VALIDATION PHASE (ESTCP)
- WORK WITH RPMS AND LOCAL/STATE/REGIONAL REGULATORS
- INTEGRATE WITH WESTERN RESULTS

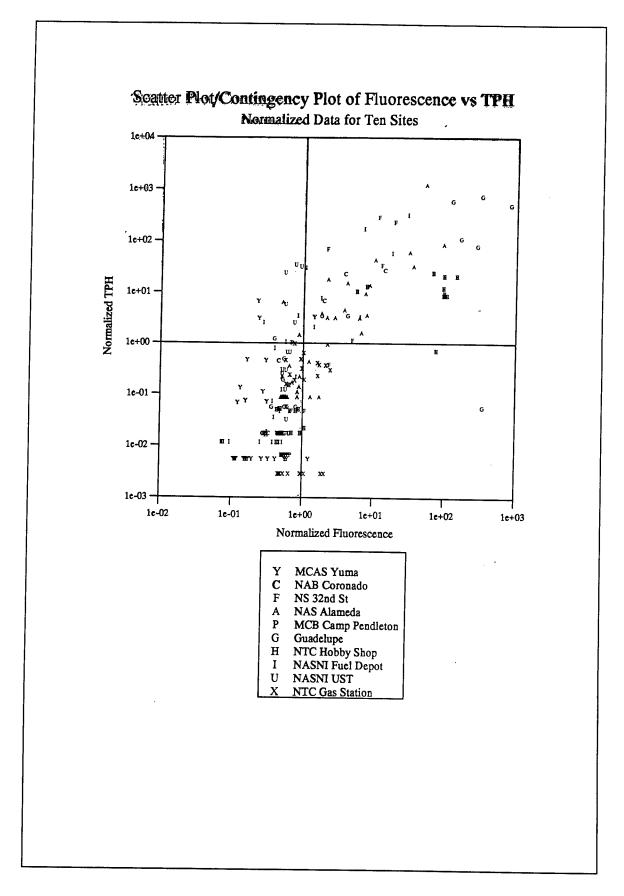


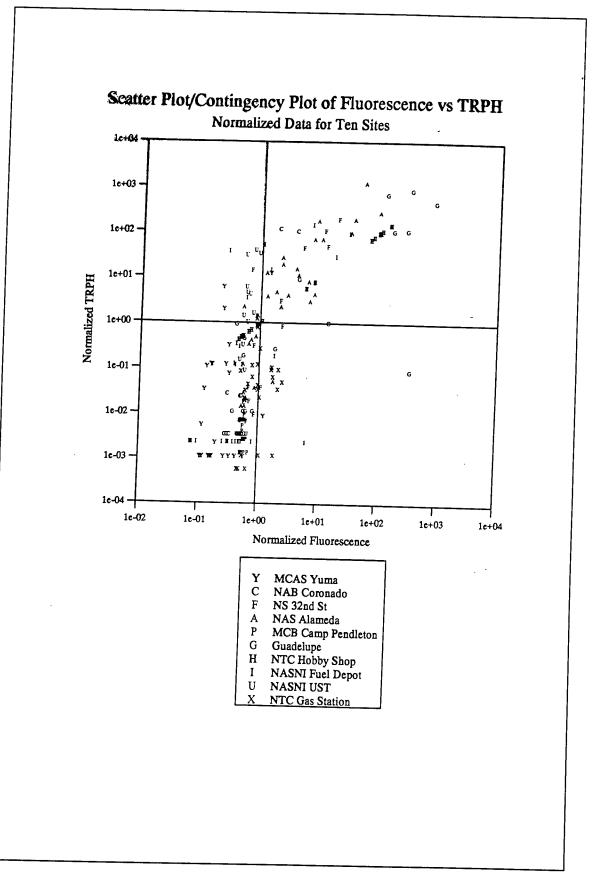


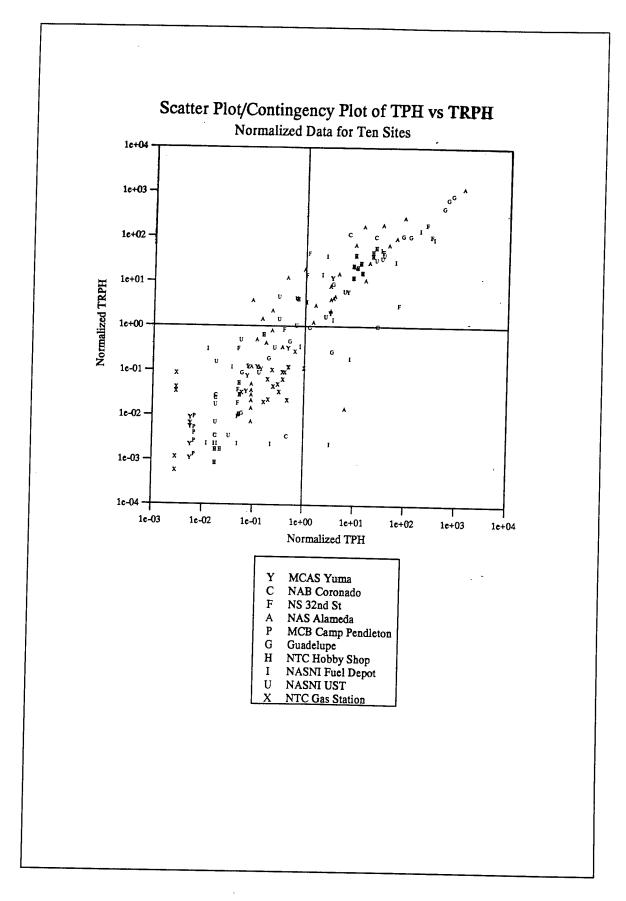


NAVY Validation Sites

- NAS North Island, Fuel Farm
 - NS San Diego, FFTF
- NAB Coronado, abandoned fuel farm
 - MCAS Yuma
- NAS Alameda, old refinery site
 - Camp Pendelton, UST
- NAS North Island, expedited tank yank
 - Guadalupe Oil Field
- NTC San Diego, gas station
- NTC San Diego, auto hobby shop







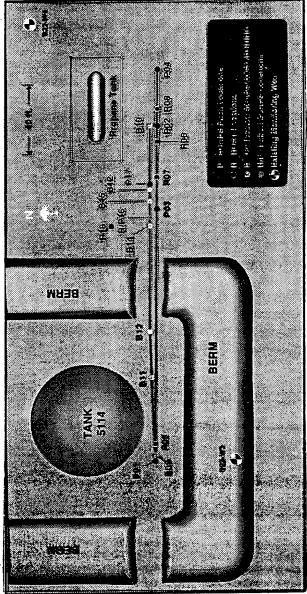
Cumulative Contingency Analysis Summary for 10 Sites (n=219)

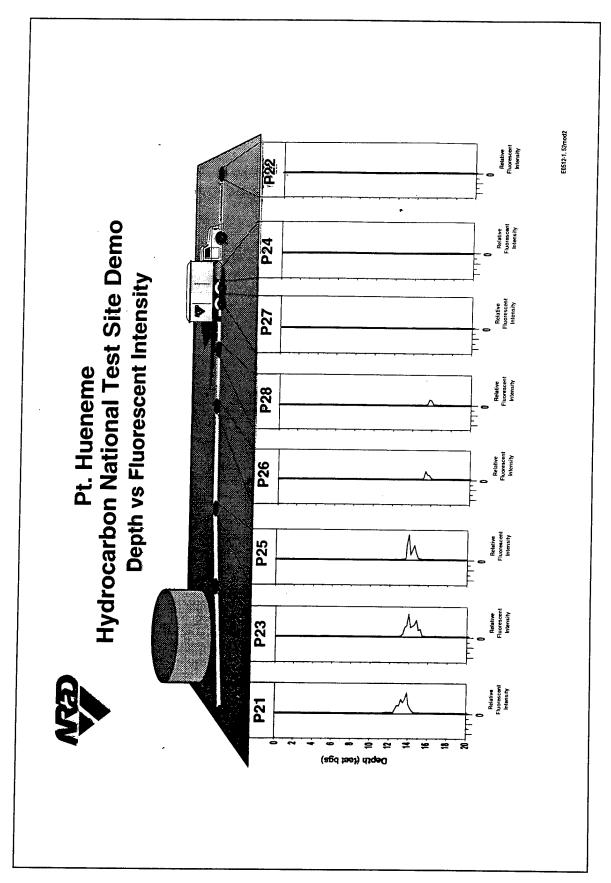
Method	% Correct	% False	% Falco
		Pos	Nos
			501
		တ	œ
)
		ර ා	9
	38.		
	ණ මා	∼	נכ
The state of the s	The state of the s	ļ: .	<u> </u>

£0611-2.62

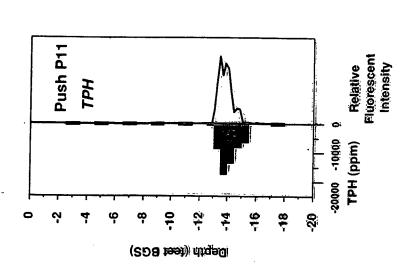
Port Hueneme National Test Site Demo



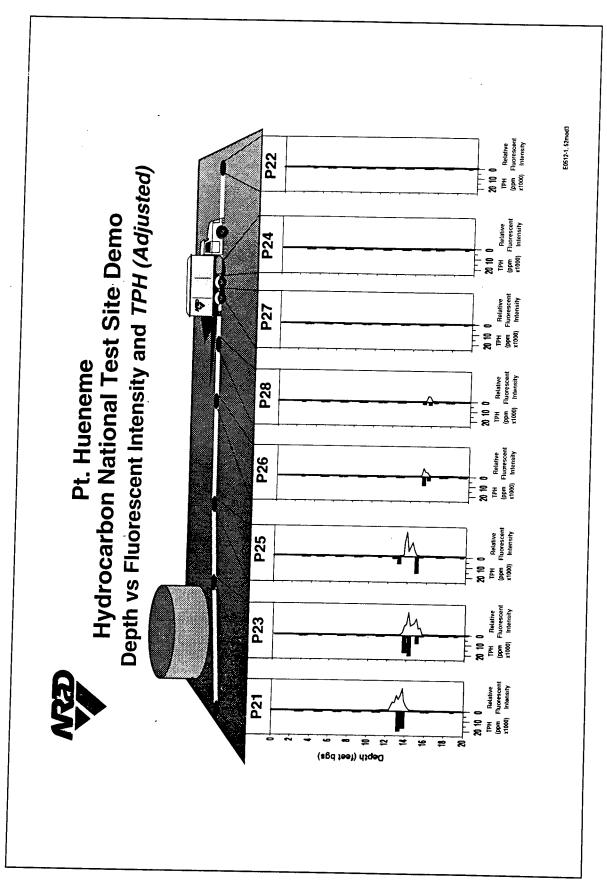




Depth vs Fluorescent Intensity











Demonstration of Direct Sparge Volatile
Organic Carbon Sampler with
Hydropunch Direct Push Groundwater
Sampler with the Site Characterization
and Analysis Penetrometer System

Lead Organization:

U.S. Army Environmental Center Aberdeen Proving Grounds, MD 21010-5401

POC:

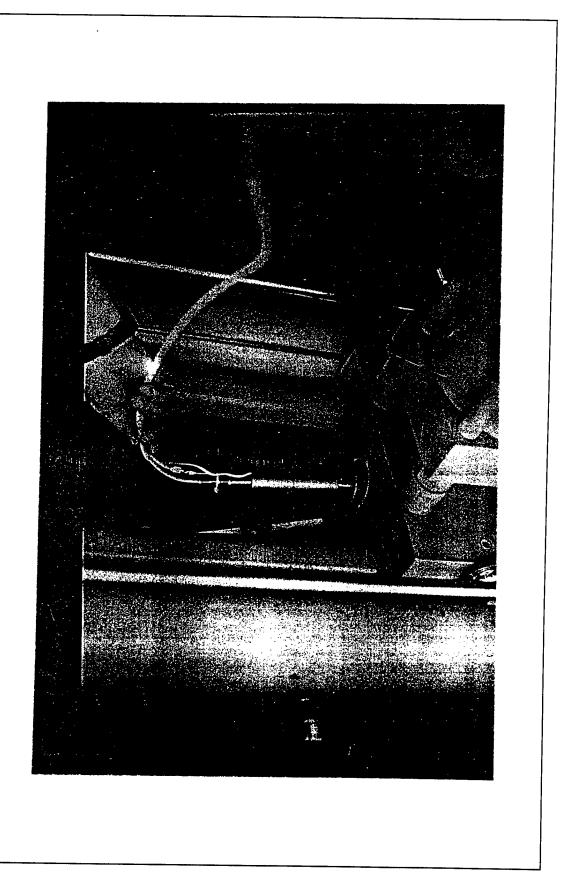
Mr. George Robitaille SFIM-AEC-ETP Voice: 410-612-6865 FAX: 410-612-6836

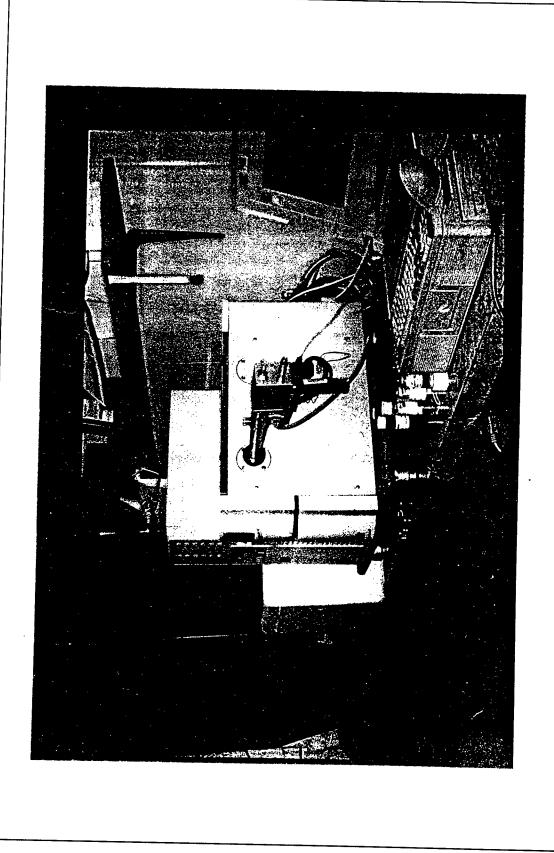


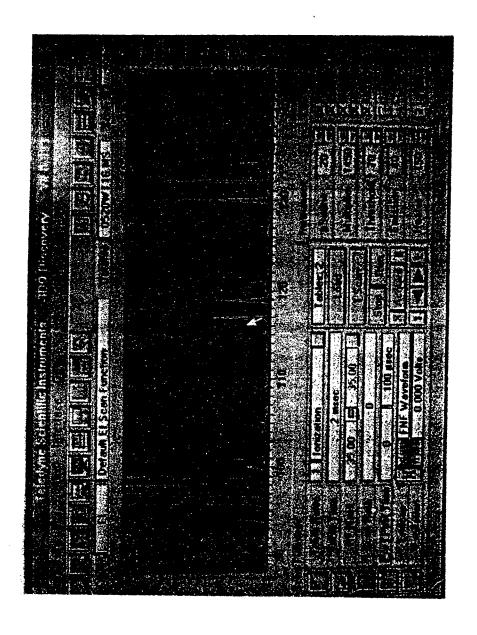
TECHNICAL DESCRIPTION

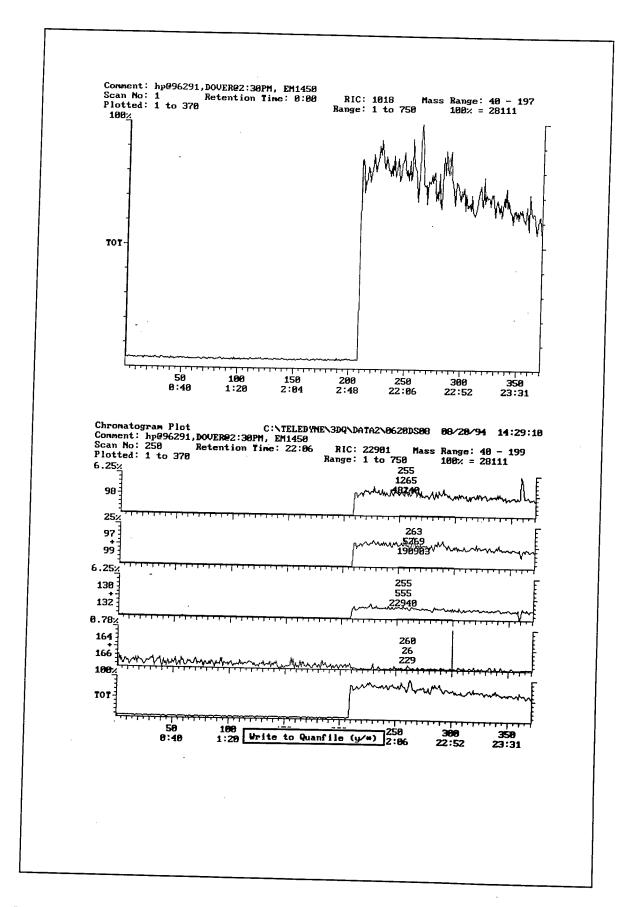


- •Hydropunch commercially available direct push groundwater sampler to access groundwater
- •Direct sparge sampler strips VOCs from groundwater in-situ and transports analytes to surface
- Analytes identified and quantified using Teledyne field portable ITMS











METHOD FOR VERIFYING TECHNOLOGY



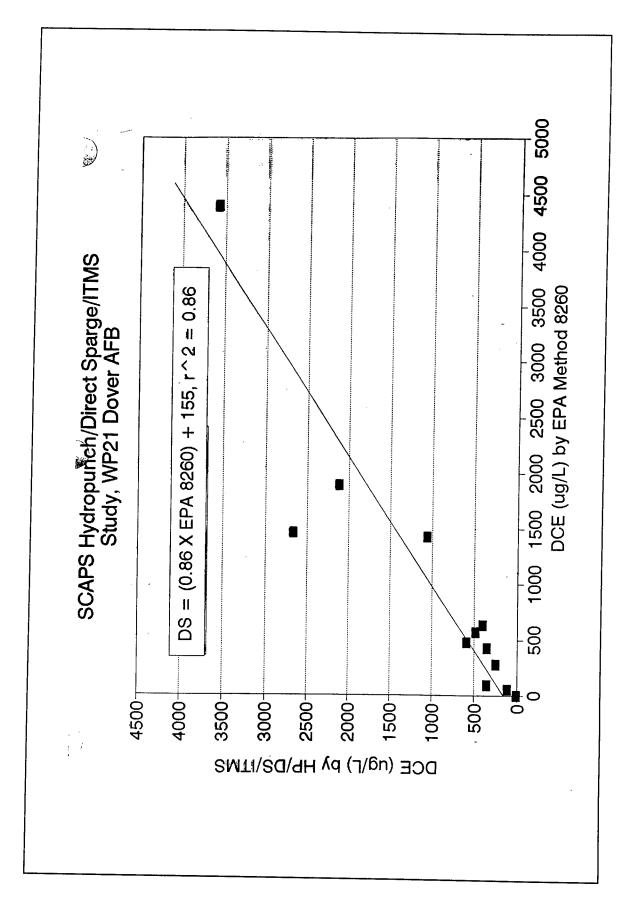
- Obtain groundwater samples from each Hydropunch/direct sparge/ITMS experiment for laboratory analysis by EPA Method 8260
- Compare Hydropunch/direct sparge/ITMS results with data obtained from conventional monitoring wells at each site
- Low flow pumping in place of bailers for collection of samples

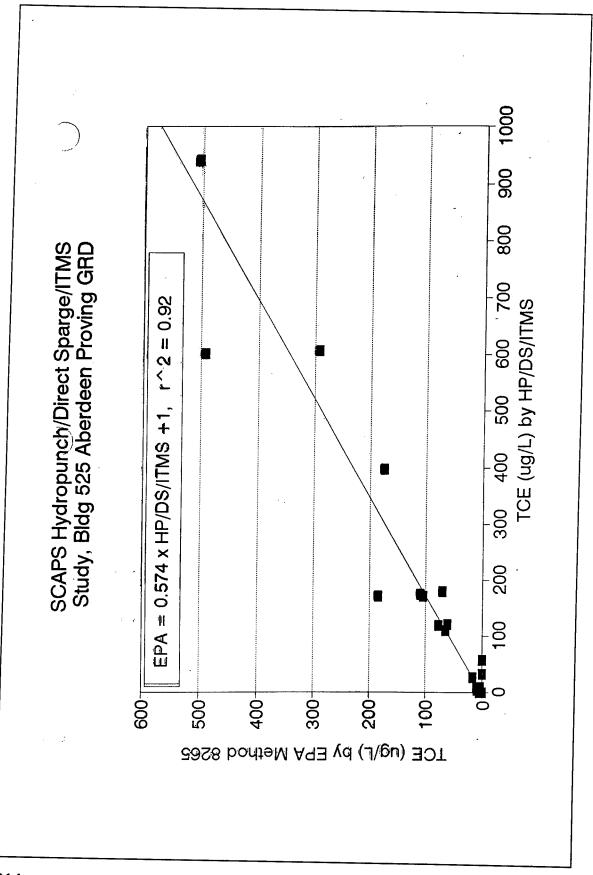


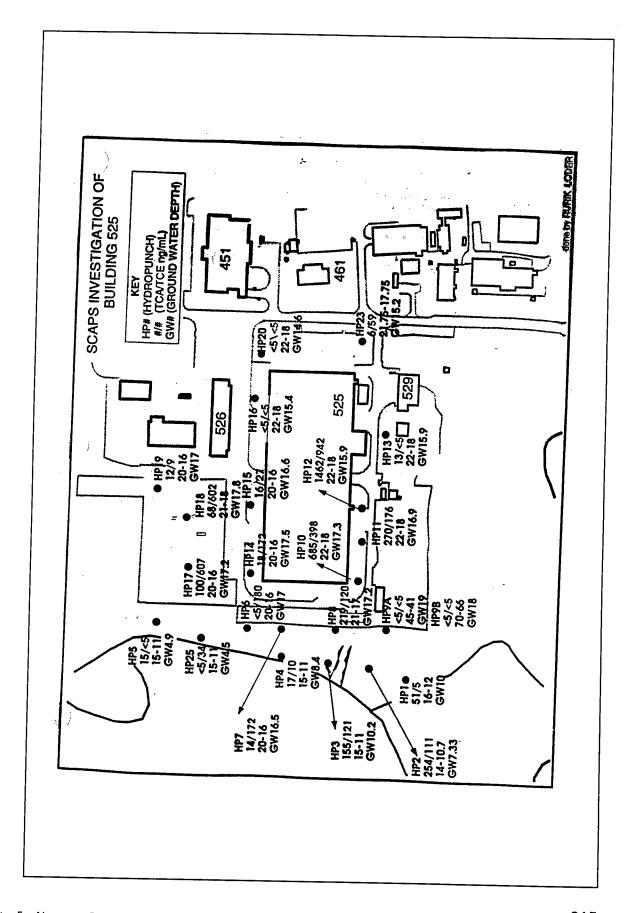
PERFORMERS



- AEC, Mr. George Robitaille, SFIM-AEC-ETP, Aberdeen Proving Grounds, MD; Project management, coordination with users and regulators
- WES, Dr. William M. Davis, CEWES-ES-P, 3909 Halls Ferry Road, Vicksburg, MS; conduct field demonstration/validation, laboratory analysis/data reduction, document results in guidance documents
- ORNL, Dr. Mark Wise, Martin Marietta Energy Systems, Inc., ORNL, P.O. Box 2008, Building 4500-S, Oak Ridge, TN; provide support and assistance with field demonstration/validation, data reduction and documentation







6 SERDP Peer Review Panel Conclusions and Recommendations

The SERDP funded Tri-Service Accelerated SCAPS Sensor Development Project is composed of seven research areas as follows:

- I. Laser Induced Breakdown Spectroscopy (LIBS) sensor development for detecting metals in soils.
- II. Laser Induced Fluorescence (LIF) sensor development for detecting
 - a. POL contaminants
 - b. Explosive contaminanants
- III. Fiber Optic Raman Sensor (FORS) development for detecting VOCs (LNAPLS and DNAPLS).
- IV. Electrochemical sensors for detecting
 - a. Explosive contaminants
 - b. VOCs
- V. Spectral Gamma probe for detecting radioactive wastes
- VI. SCAPS sampler development
 - a. Thermal desorption VOC sampler
 - b. Multiport sampler
- VII. Data processing methodologies to provide on site 3-D visualization and to interface emerging sensors into the SCAPS data acquisition, processing, and visualization systems

The SERDP project briefings were arranged in the order listed above and the briefing materials are included in this chapter. Since some of the research areas are being pursued by multiple Tri-Service partners, some of the research areas contain more than one set of briefing materials.

7 User Needs

SCAPS users from the Army Corps of Engineers Districts, the EPA, and DOE were invited to attend and to participate in the presentations and discussions. Mr. Arbor Drinkwine of the Kansas City District of the Corps of Engineers presented a video describing their innovative over coring technique used to verify SCAPS LIF sensor responses. This technique has been very useful in reducing the effects of soil/contaminant heterogeneities, and for comparing LIF sensor results with EPA approved methods in order to obtain regulatory acceptance of SCAPS technologies. Mr. Bob Lien of the Environmental Protection Agency, Ada OK, presented a slide briefing of a different coring technique that is also applicable to the verification of SCAPS sensor responses. Due to the format of these presentations, no hardcopy materials were available for inclusion in this report.

8 DOE Related Research

A number of DOE and EPA researchers were invited to attend the workshop and to make presentations on their ongoing research that is relevant to the SCAPS sensor development effort. This chapter contains the unedited briefing materials submitted for this portion of the workshop.

On-Line Organic Samplers for the Cone Penetrometer

P.V. Doskey, J.H. Aldstadt, and M.D. Erickson

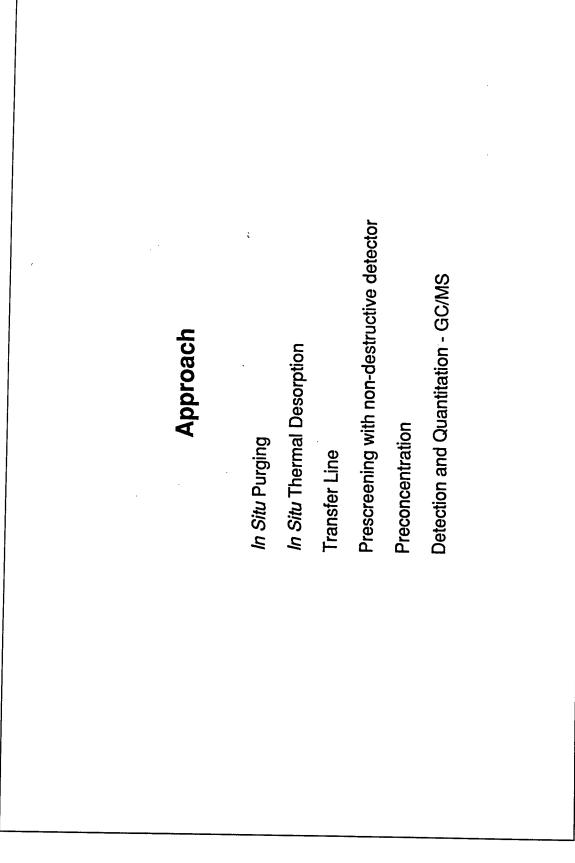
Environmental Research Division Argonne National Laboratory

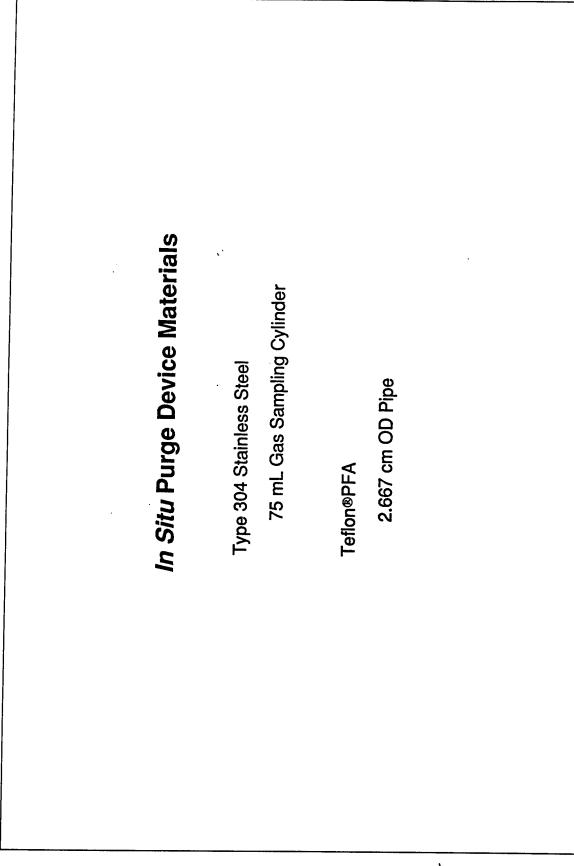
A. Robbat

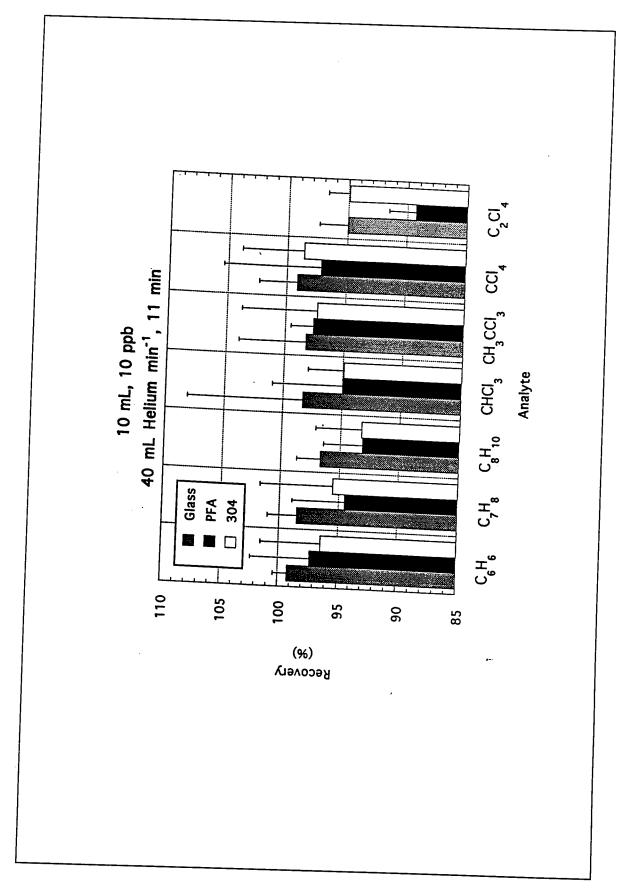
Chemistry Department Tufts University

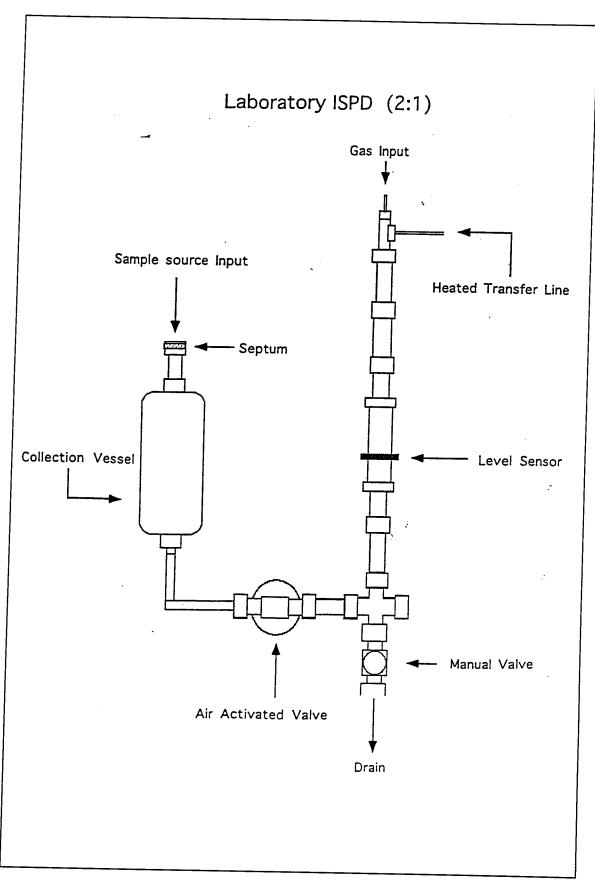
	Objective	Approach	Results	In Situ Purge Device	Thermal Desorption Device	Transfer Line	Conclusions	FY 96 Plans		

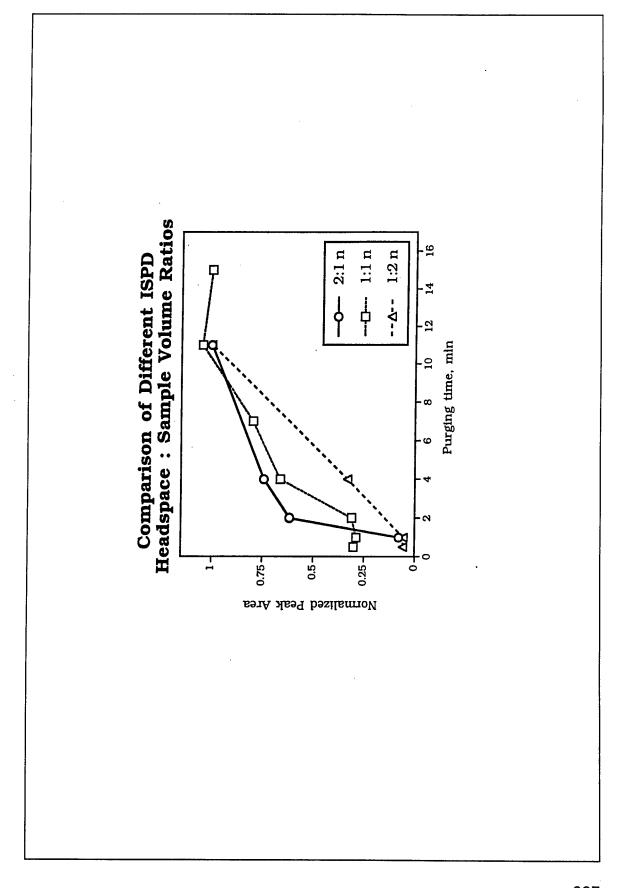
To provide in situ, on-line analyses for VOCs and SVOCs in subsurface materials. Decrease the cost of site characterizations Increase speed of data acquisition Eliminate sample manipulation **Objective** Maintain sample integrity

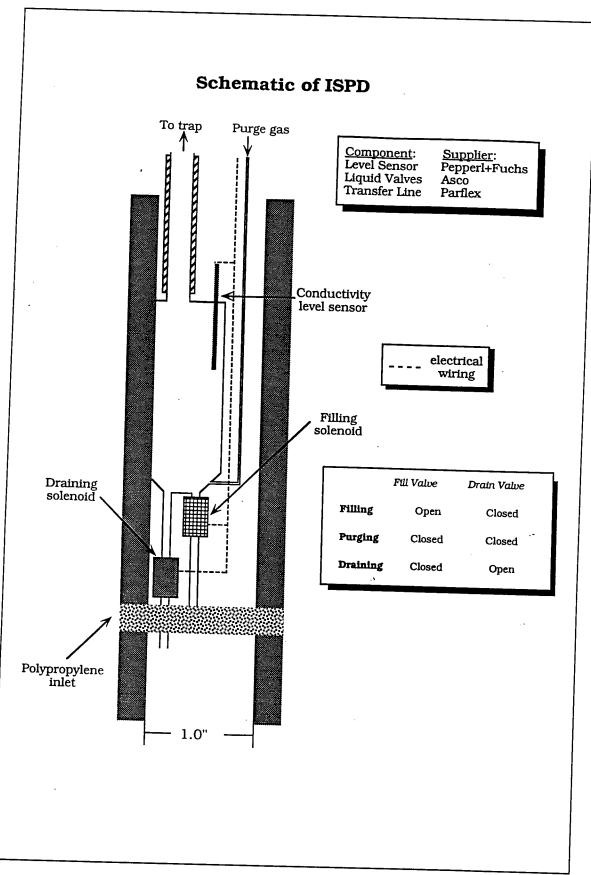


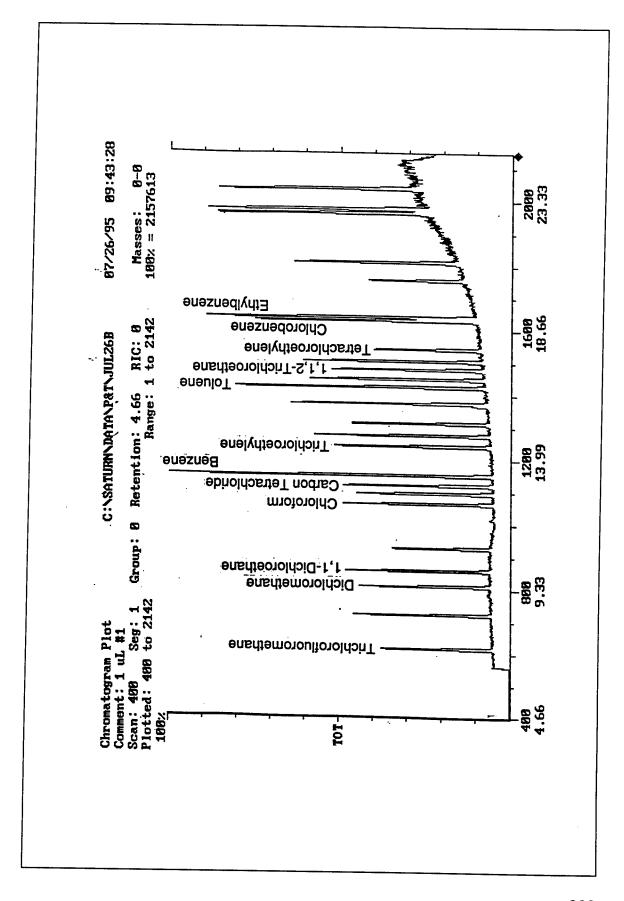












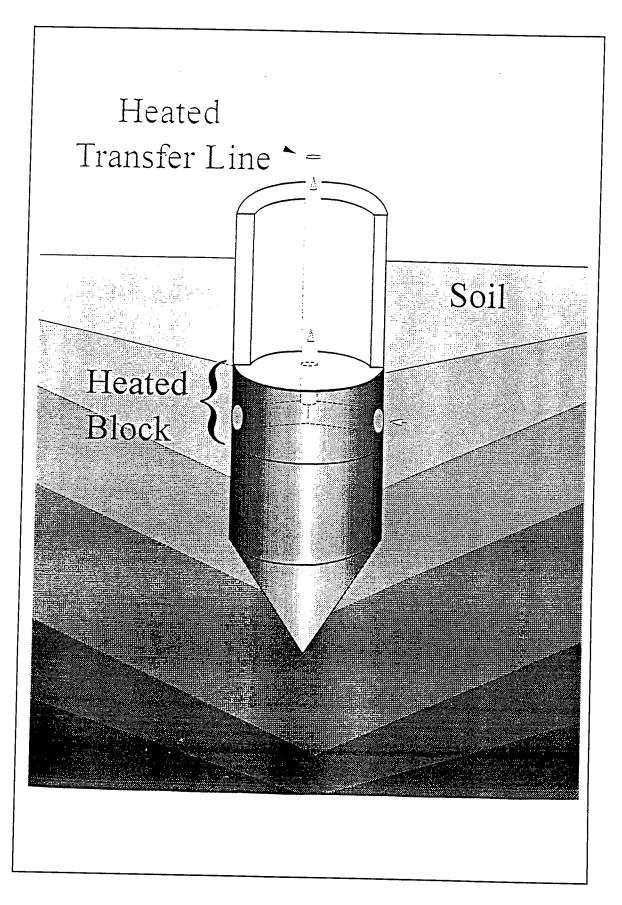
Conclusions

In Situ Purge Device

Sparging efficiencies for vessels made of glass, Teflon®, and stainless steel are similar.

The optimum headspace to sample volume ratio for a purge vessel is 2:1.

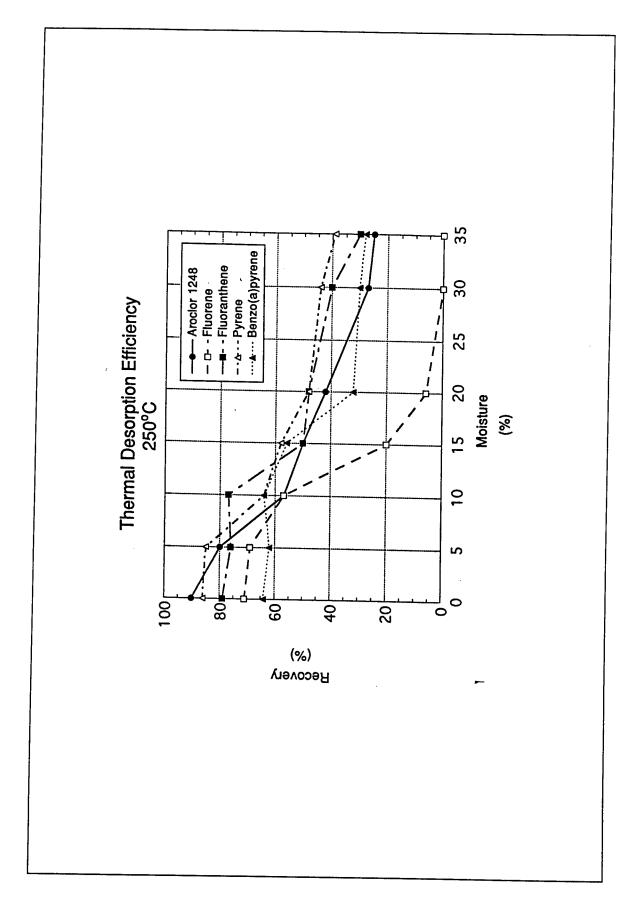
A stainless steel ISPD has been integrated within a CPT push rod that employs microvalve technology and a conductivity level sensor to accurately purge a 5 mL groundwater sample as described in EPA Method 624.

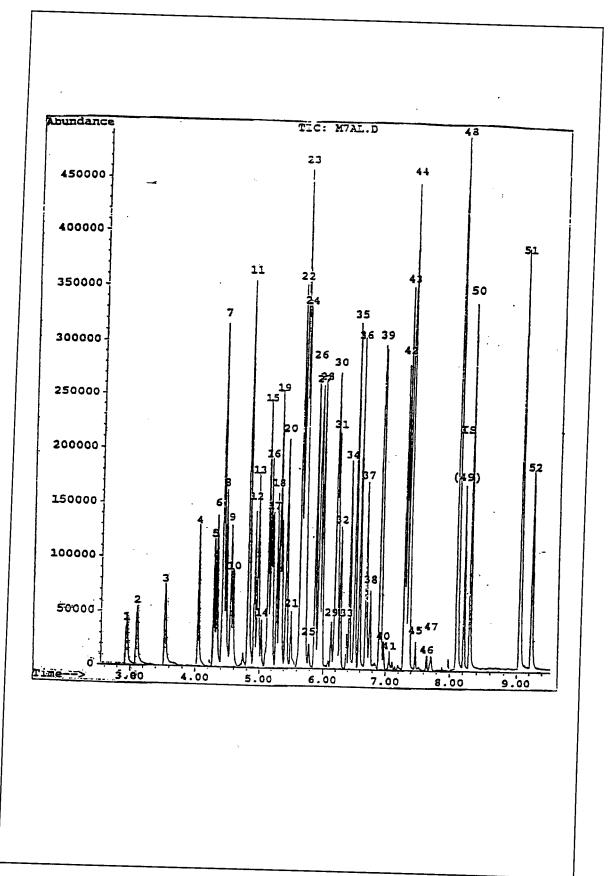


Material Balance for Standard Addition to Dry Sand

A A						
Analyte	Trans	Transferred	Residua	Residual in Soil	Residual in	ual in
	ల	(%)	6)	(%)	I ransf (%	I ransfer Line (%)
	250°C	300.0	250°C	300.0	250°C	300.0
Aroclor 1248	92.4	95.2	5.03	3.10	2.23	0.31
BHC	87.1	91.0	12.0	6.80	0.00	000
Dieldrin	73.1	0.99	26.0	18.6	0.50	030
4,4'-DDT	67.3	72.3	19.1	13.4	4.50	000
Fluorene	71.5	75.4	0.00	2.82	1.95	0.63
Fluoranthene	79.0	80.2	4.50	4.40	3.40	2,68
Pyrene	86.3	82.9	9.00	6.21	1.59	1.40
Benzo ^r vyrene	64.5	65.4	31.0	23.1	3.90	2.50

28 ppm 12 ppm 15 ppm





Instrument Calibration

Analyte	Dynamic Range	Detection Limit	RSTD
	(ng)	(bu)	(%)
α-BHC	0.5 - 1000	0.5	9
PCB (CI-4)	3.7 - 950	4.0	æ
Fluoranthene	0.5 - 1000	0.7	
Pyrene	0.5 - 1000	1.3	. 25
Dieldrin	0.5 - 1000	0.7	.
4,4'-DDT	0.5 - 1000	0.5	=
Dibenz[a,h]anthracene	0.5 - 1000	9.0	14

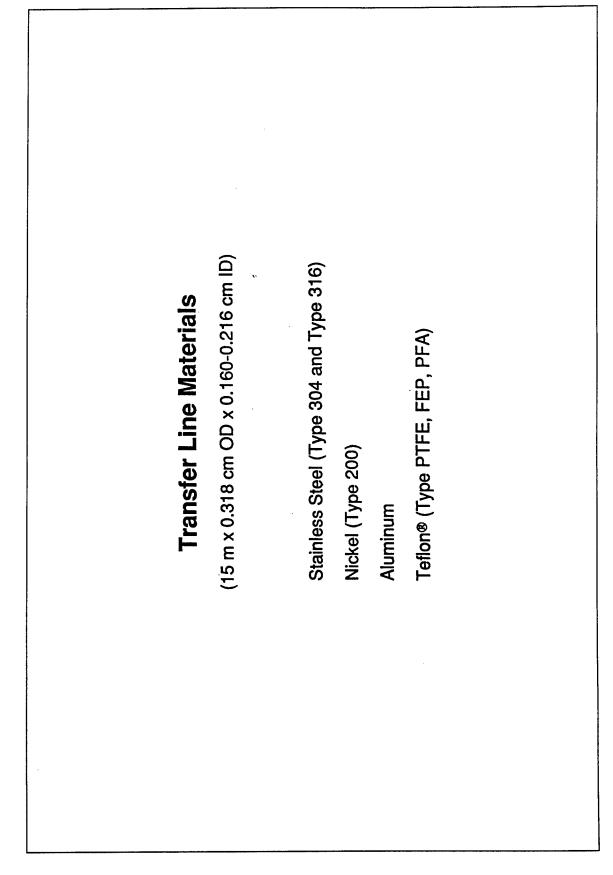
Conclusions

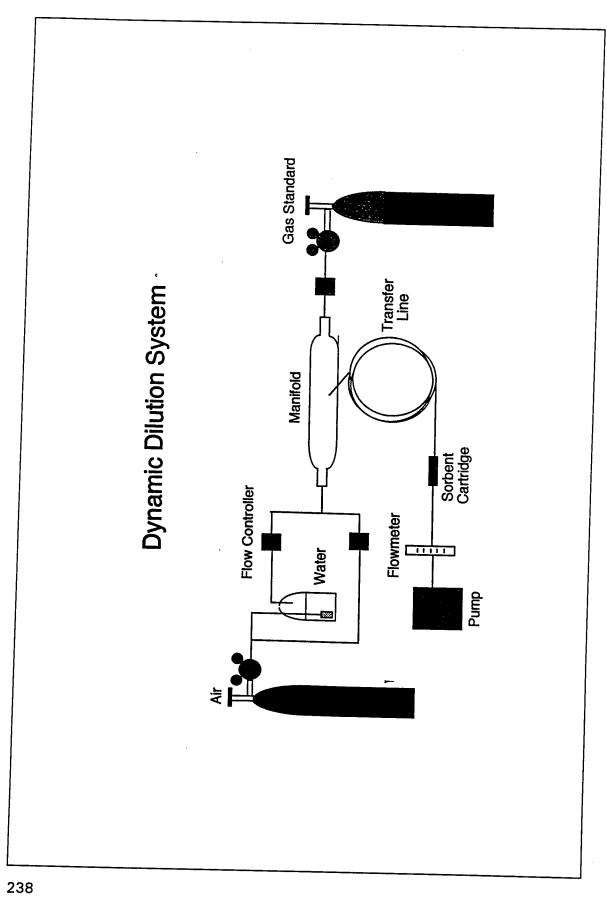
In Situ Thermal Desorption Device

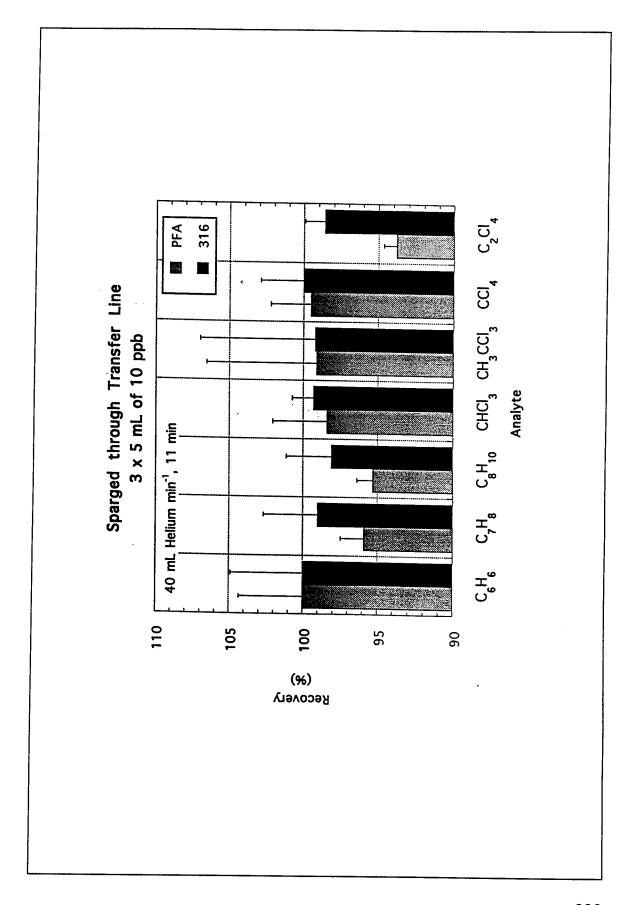
A temperature of 250°C is sufficient to thermally desorb PCBs, PAHs, and pesticides from a dry sample matrix with 50-95% efficiency.

Volumetric flow rates of 15 - 60 mL min-1 and purge volumes exceeding at least 30 volumes of the thermal desorption system are necessary to efficiently transfer the desorbed analytes and preconcentrate them on glass wool at -60°C.

The thermal desorption efficiency decreases with increasing water content of the matrix.







Conclusions

Transfer Line

Stainless steel is superior to Teflon® as a transfer line material.

Gentle heating to prevent condensation of water in the transfer line will be necessary for efficient VOC transfer.

Glass-Lined or passivated stainless steel tubing may be necessary to efficiently transfer SVOCs from the thermal desorption device.

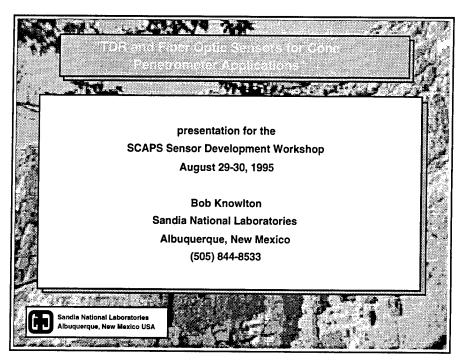
FY 96 Plans

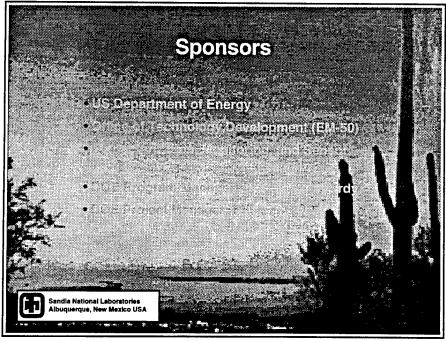
Field test of on-line organic samplers at ANL.	10/95 - 11/95	۳
Laboratory Test of Thermal Desorption Device for VOCs.	10/95 - 11/95	5
Modify samplers.	12/95 - 2/96	9
Field tests of on-line organic samplers at additional sites.	3/96 - 96/8	9

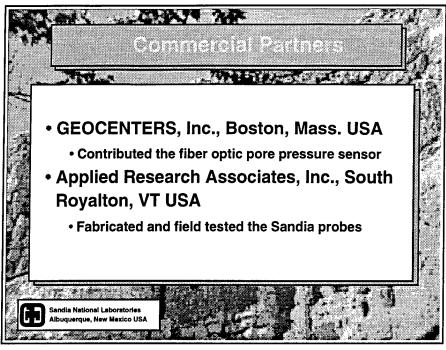
Acknowledgment

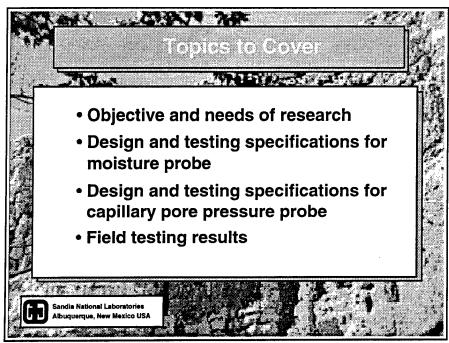
Charles H. Batson Molly S. Costanza Aleksandr Gorshteyn Tammi R. James Jacqueline M. Kuo Alice F. Martin U.S. Department of Energy Characterization, Monitoring, and Sensor Technology Integrated Program Office Technology Development

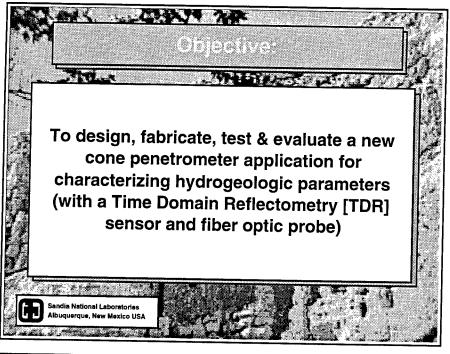
lanager: Caroline Purdy ager: Eric Lightner

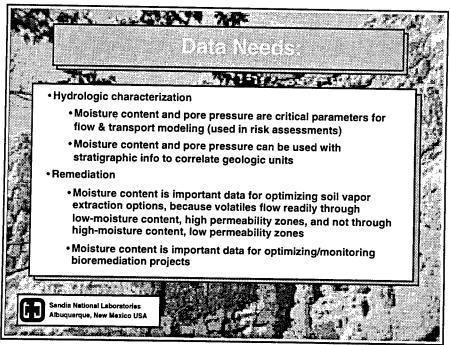


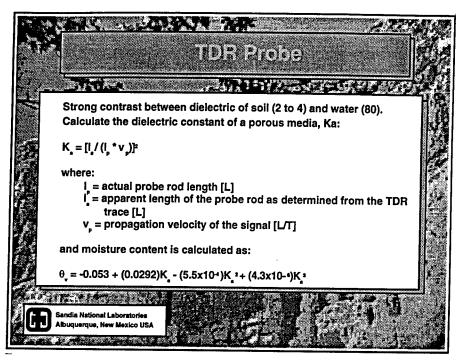


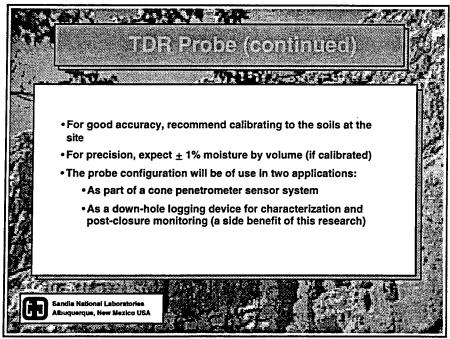


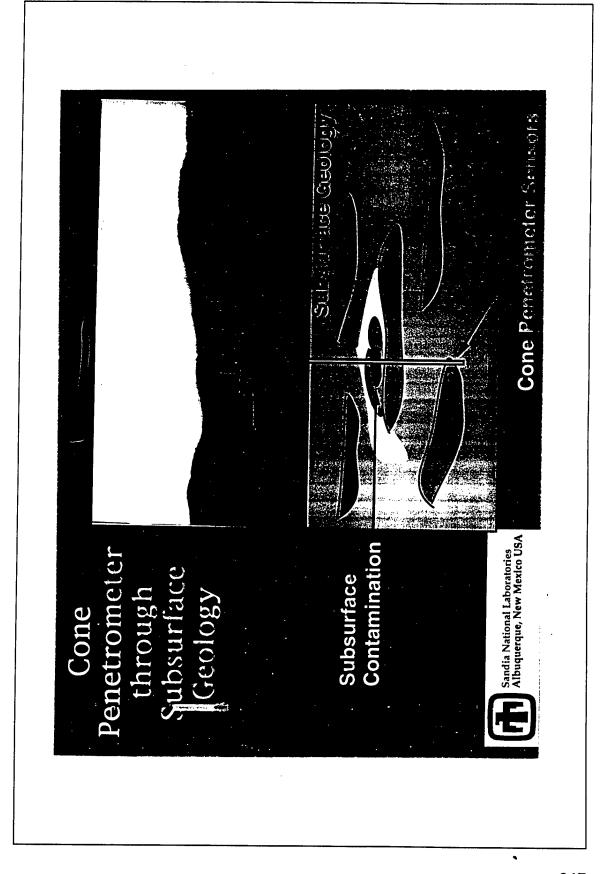


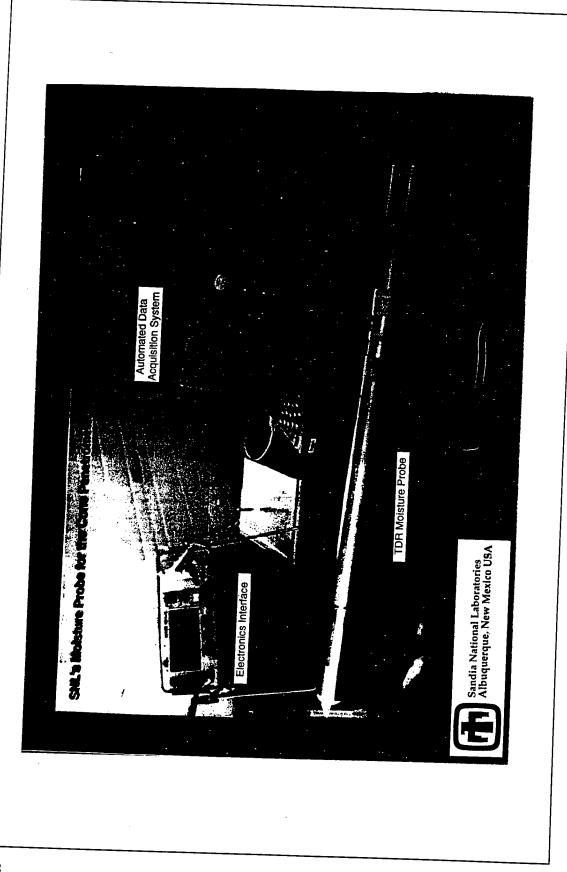


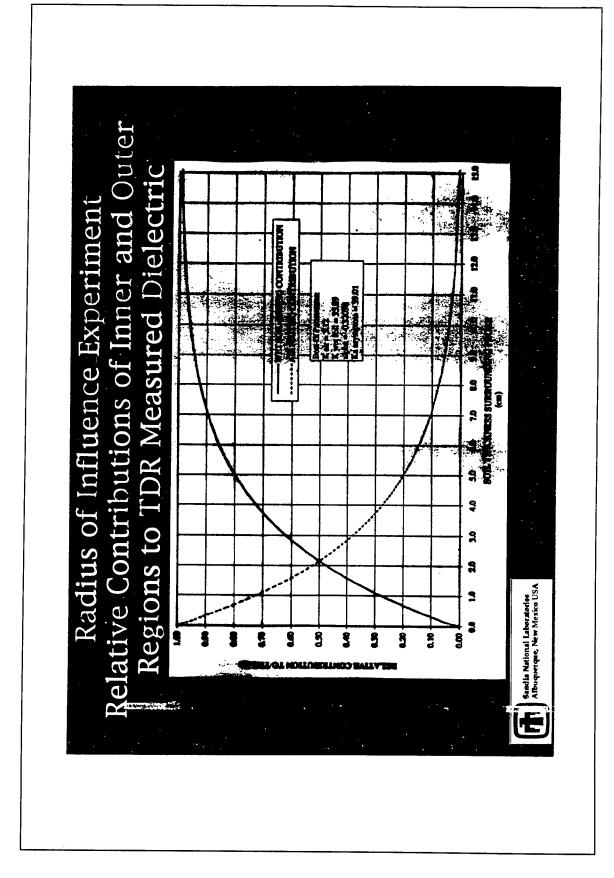


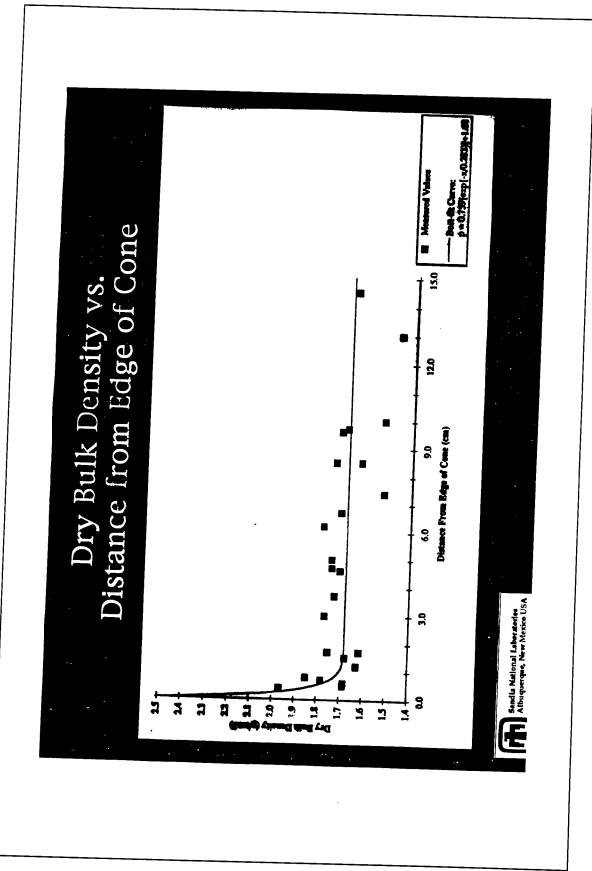


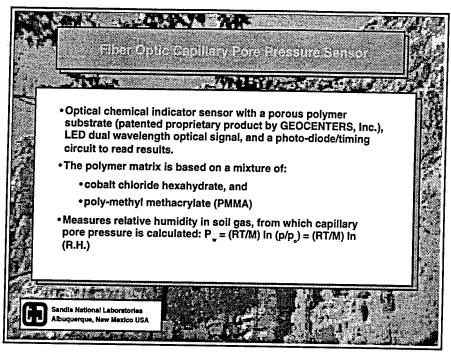


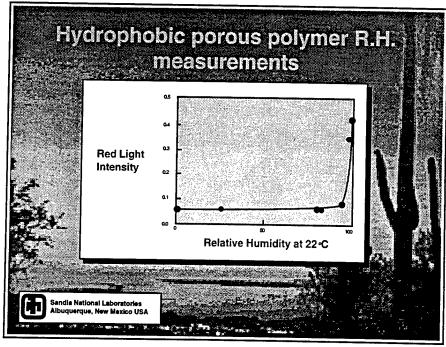


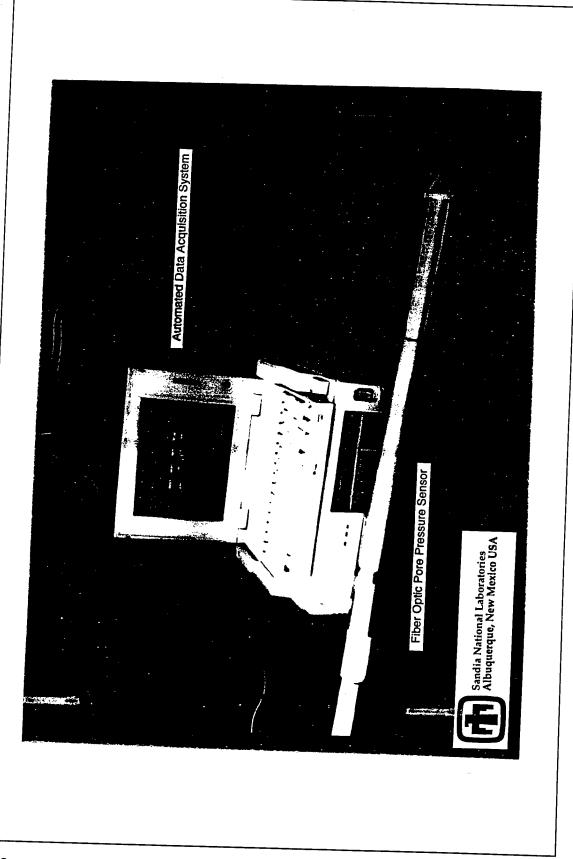


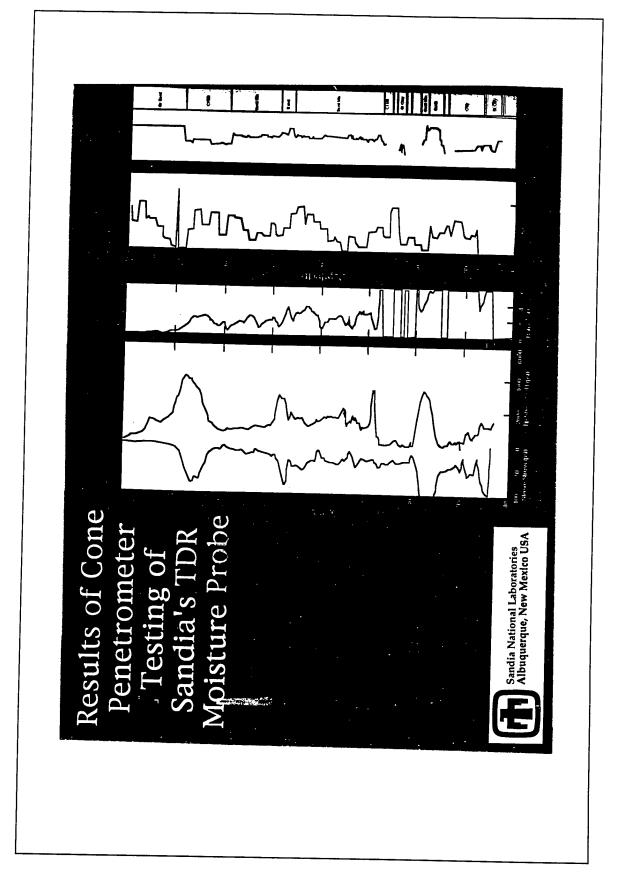


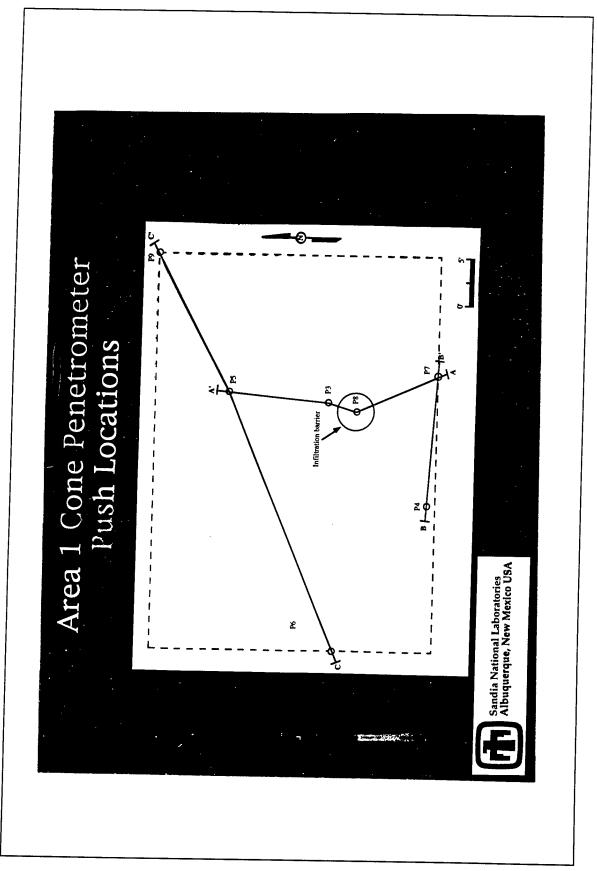


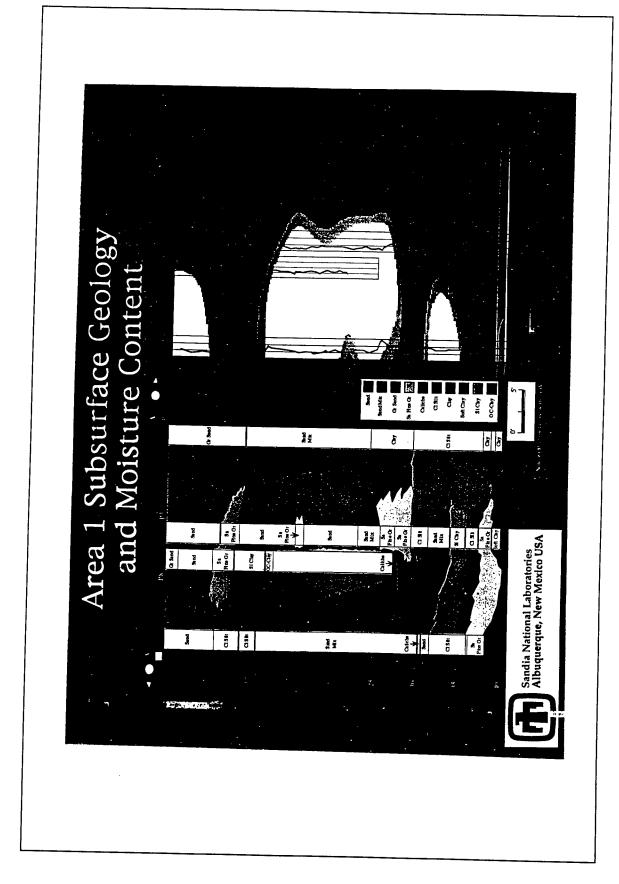


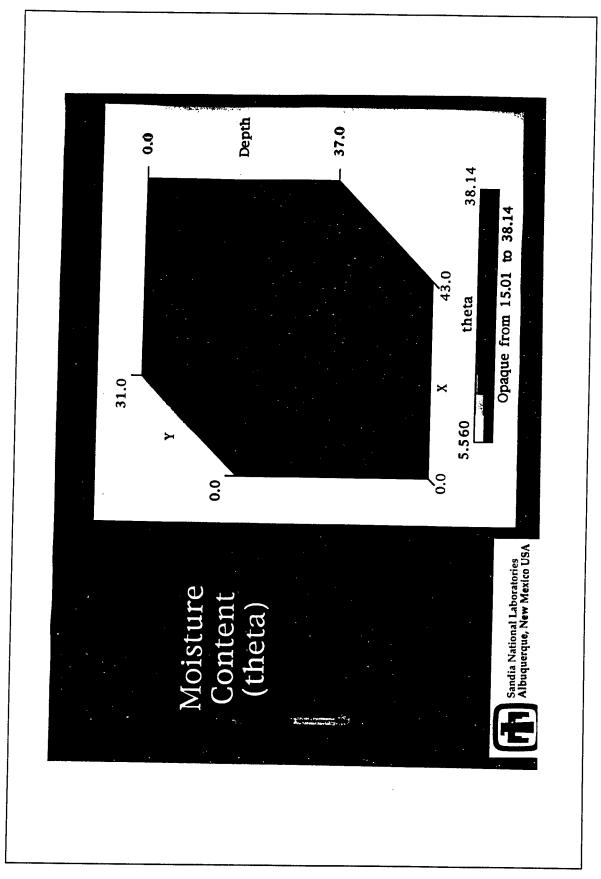


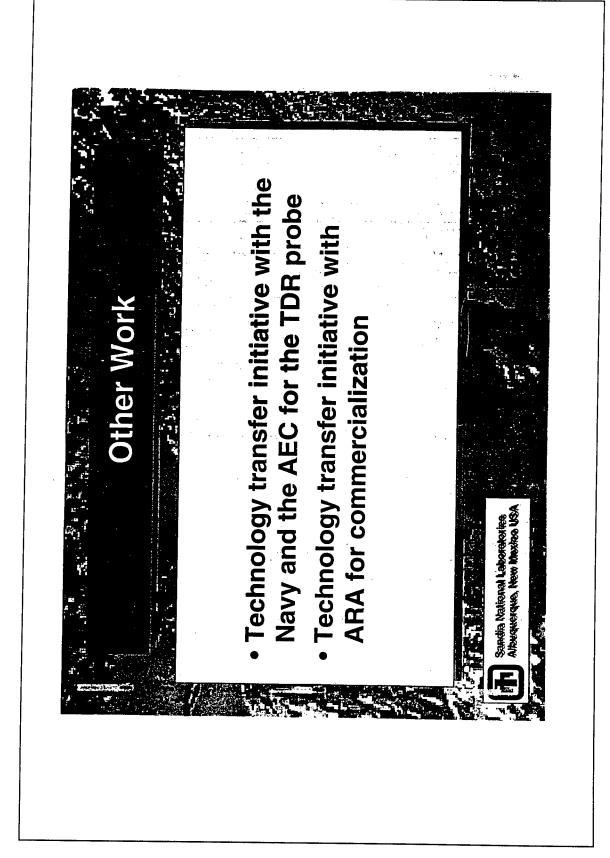


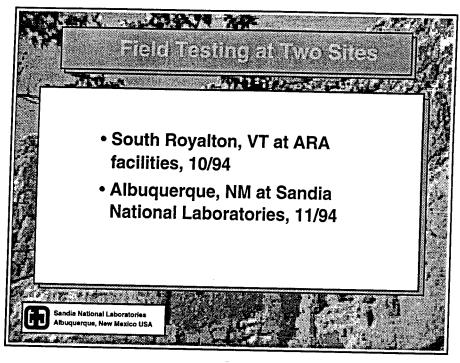


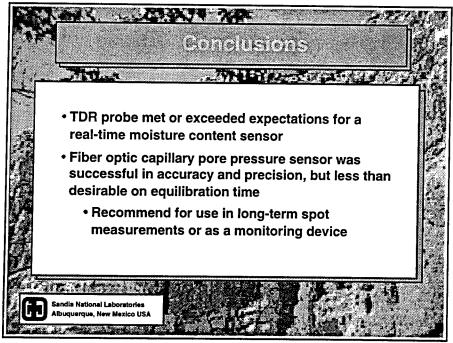












Fiber Optic IR Cone Penetrometer for Site Characterization

A research and development program funded by the U.S. Army Environmental Center

Sponsor: Mr. George Robitaille, AEC

Participants:

- Naval Research Laboratory Washington
 - Dr. Ish Aggarwal (PM)
 Dr. Frank Bucholtz (PI)
- US Geological Survey
 Army Waterways Experiment Station

OBJECTIVES

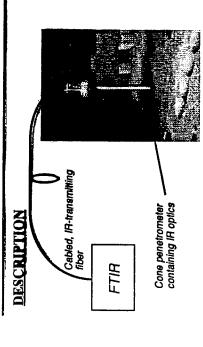
- Develop fiber optic sensors to provide remote, in-situ detection of hydrocarbon contamination in soil for screening and characterization of environmental sites.
- Perform field tests in conjunction with SCAPS.

APPROACH

• Integrate infrared optics, FTIR spectroscopy and newly-developed IR transmitting chalcogenide fibers to produce a field-ruggedized sensor system.

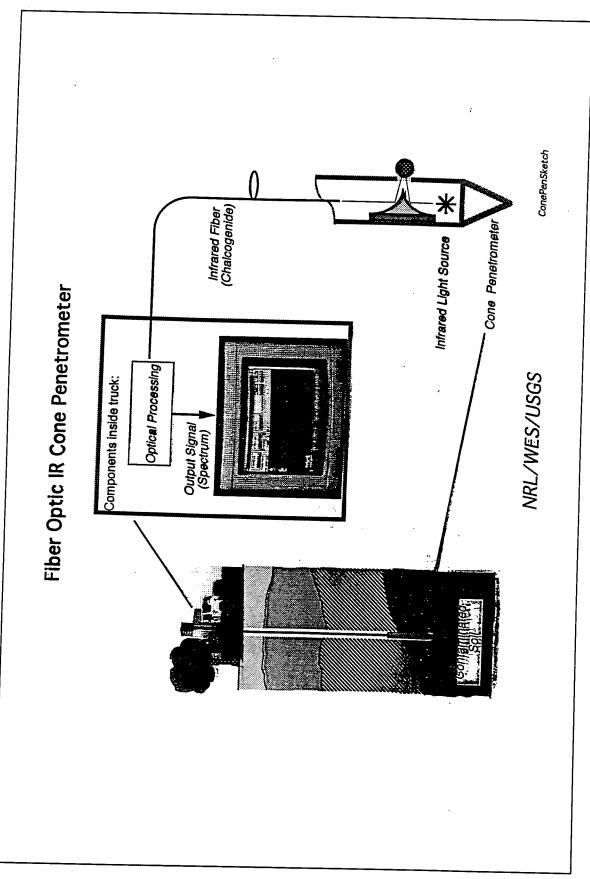
DELIVERABLE

• IR fiber optic sensor system for in-situ detection of hydrocarbon contaminants in soils.

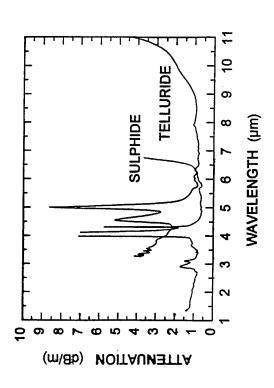


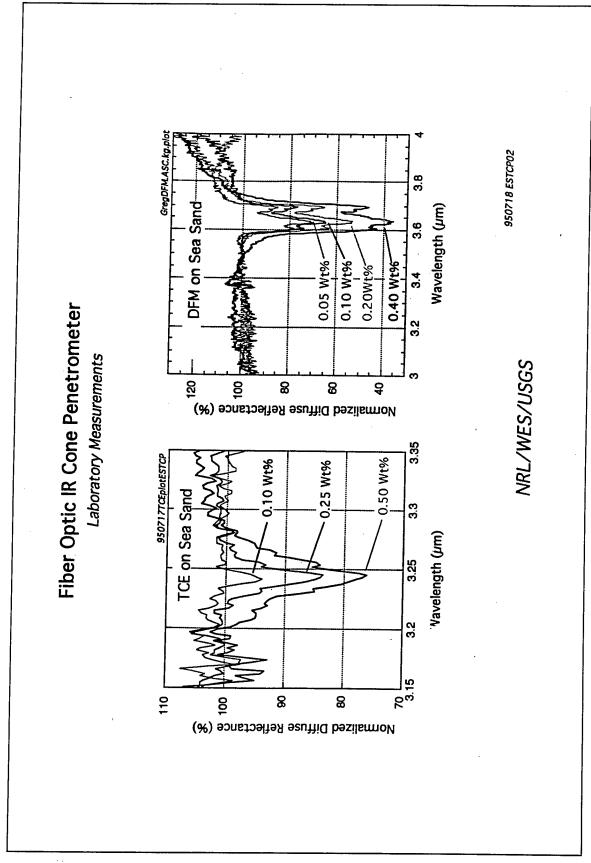
Naval Research Laboratory

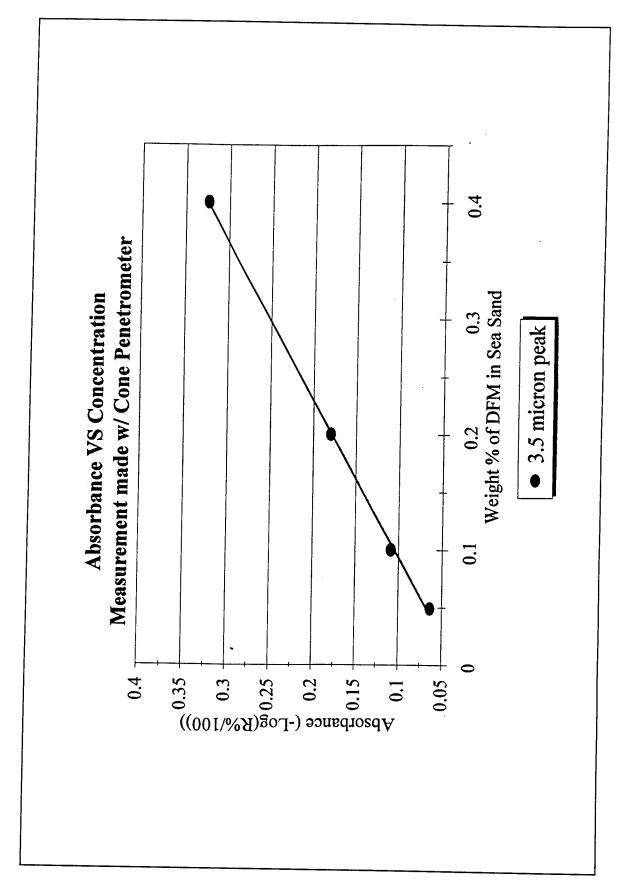
950710ia.chemquadchart



GLASS CLADDED FIBERS







SUMMARY

Pre-Dover Laboratory Results on Cone Penetrometer System

Detection Limit (ppm)	20	200	200		
Conditions	SAND, Large Sample, No fiber	SAND, Penetrometer, Cabled fiber	SAND, Large Sample, Cabled fiber		
Contaminant	DFM	DFM	TCE		

950707 pre-D

TECHNICAL ISSUES

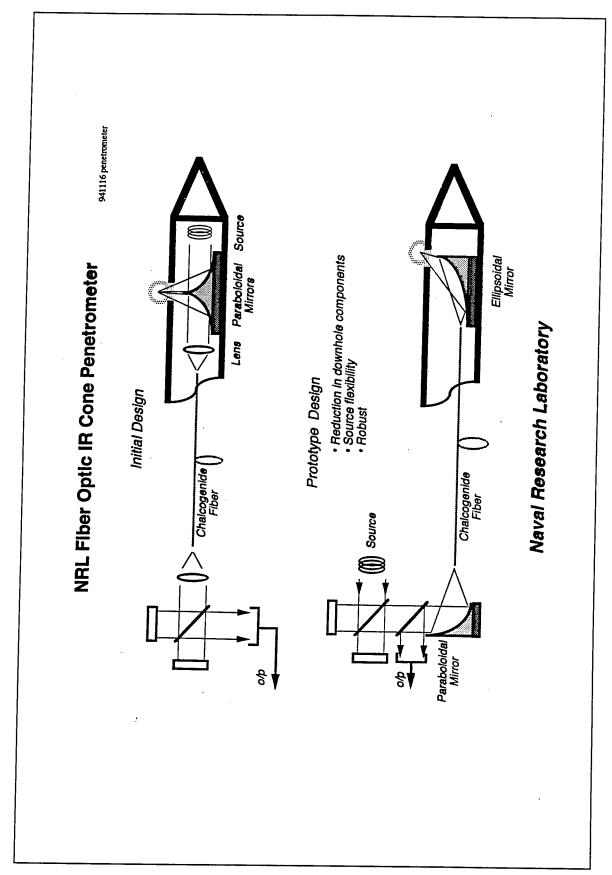
Pre-Fabrication Stage (Fall '94)

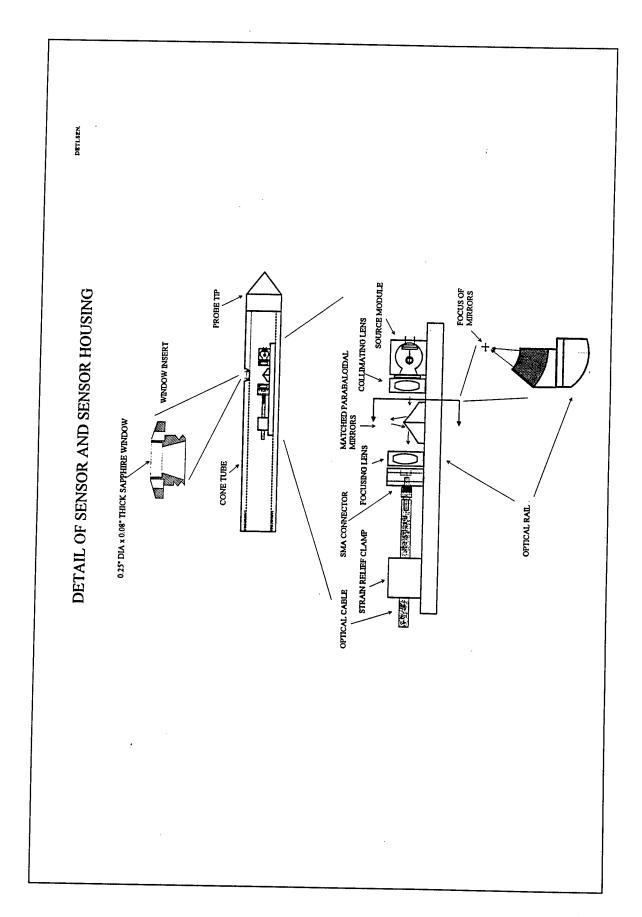
Reduction in optical throughput

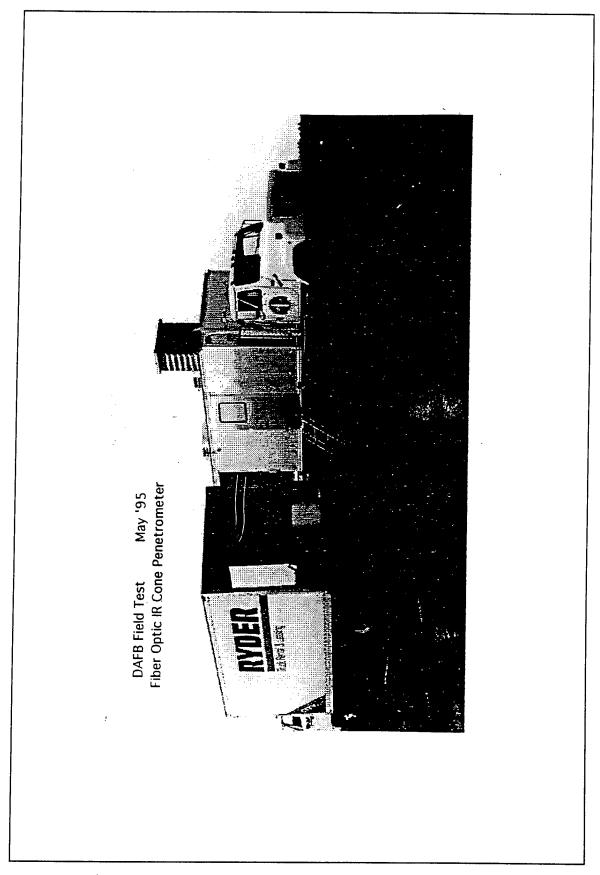
1. Miniaturization of optics

- Custom fabrication
- 2. Robustness of chalcogenide fiber cabled to useful lengths
- 3. Ruggedness and modularity of system (downhole optical rail, topside spectrometer)
- 4. Suitability of downhole source
- Reliability
- Effect of increased temperature on fiber, optics

250707 techteru

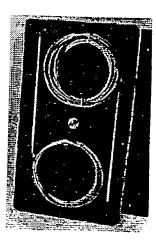






Fiber Optic IR Cone Penetrometer

Hardware and Performance



Two probes with cables attached



Cabled, IR-transmitting fiber on rack in SCAPS truck

Summary: Bover AFB Field Test, May 1995

- Quick set-up (<1 hr)
- All hardware performed properly
- No failure/breakage in IR fiber cable during normal handling and operation in SCAPS

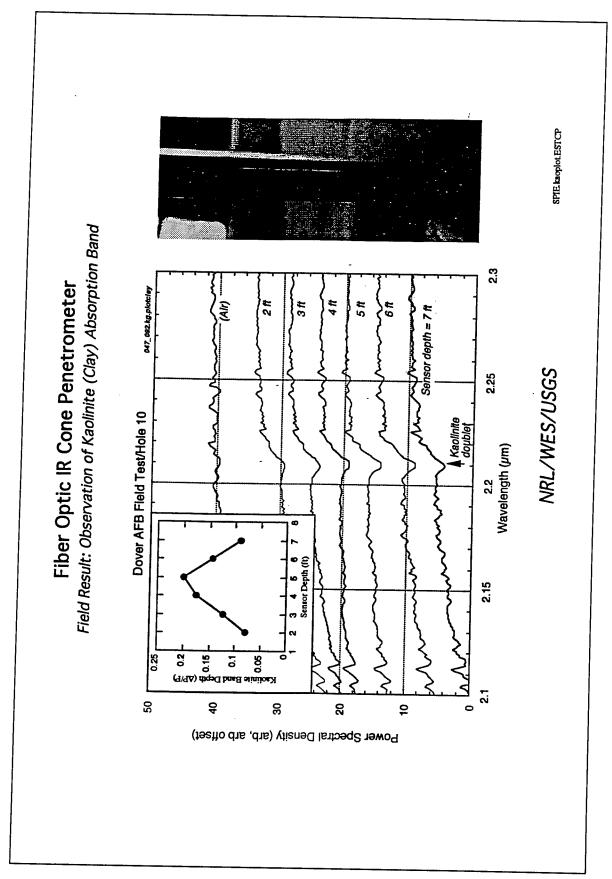
Performance of cabled IR fiber

Wavelength range of operation: 1.5 - 5.5 µm*

Total Optical Throughput (all wavelengths) Field vs Lab: > 90% * FLImited by bulk optical components. Fiber itself extends to $\geq 10~\mu m$.

NRL/WES/USGS

950718 ESTCP04



DAFB SPECTRA OF KAOLINITE LABORATORY STANDARDS - KAOLINITE USGS COMPARISON OF SPECTRA FROM DAFB WITH TWO LABORATORY STANDARDS OF KAOLINITE. type o to Change SCALE, e to ERASE, x to EXIT, or return to co ntinue 1625 (spd0075) file= v 2.20 Mavelength (microns) KACLINITE CHS #9,PFN=1,200,R history= 0.20 0,15 0.10 0.05

SUMMARY of TEST RESULTS DAFB Field Test, May 1995

Demonstrated rugged sensor system comprising IR-transmitting fiber cable, cone penetrometer optics, and spectrometer.

- Quick set-up (< 1 hr)
- Harware functioned properly
- No special cable handling required
- Optics continued functioning after penetrometer tube was bent

Successfully observed kaolinite (clay) absorption spectra & variation of absorption band with depth & location

Hydrocarbon bands not observed due to combination of low/unknown concentration levels and remaining technical issues:

- Low soil albedo compared to background
- Competing absorption bands in soil, optics (H20, HS)
 - Interfering hydrocarbon bands

950707 summitest

PROPOSED SYSTEM IMPROVEMENTS (Based on Dover AFB Field Test Results)	Solution	Improve optical throughput (x 25 expected)7-Fiber bundle	CPC collector mirror	 Paraboloidal exit mirror 	 AR coating 	 Replace KBr optics with CaF2, ZnSe optics 	 Improve fiber materials 	 Improve purge system 	 Reduce CH contamination in fiber & optical system
PROPOSED (Based on Dov	Technical Issue	 Low soil albedo compared to background 				 Competing absorption bands 			 Interfering hydrocarbon bands

950707 improv

IR PROBE COLLECTION OPTICS ENHANCEMENT

COMPOUND PARABOLIC CONCENTRATOR (CPC)

TRADE AREA FOR NA

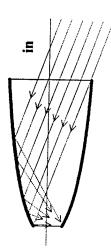
ALLOWS FOR CLOSE TO THEORETICAL MAXIMUM
CONCENTRATION OF INCOMING RADIATION (NA OUT =1)
Cmax = (1/SIN[THETAin])^2

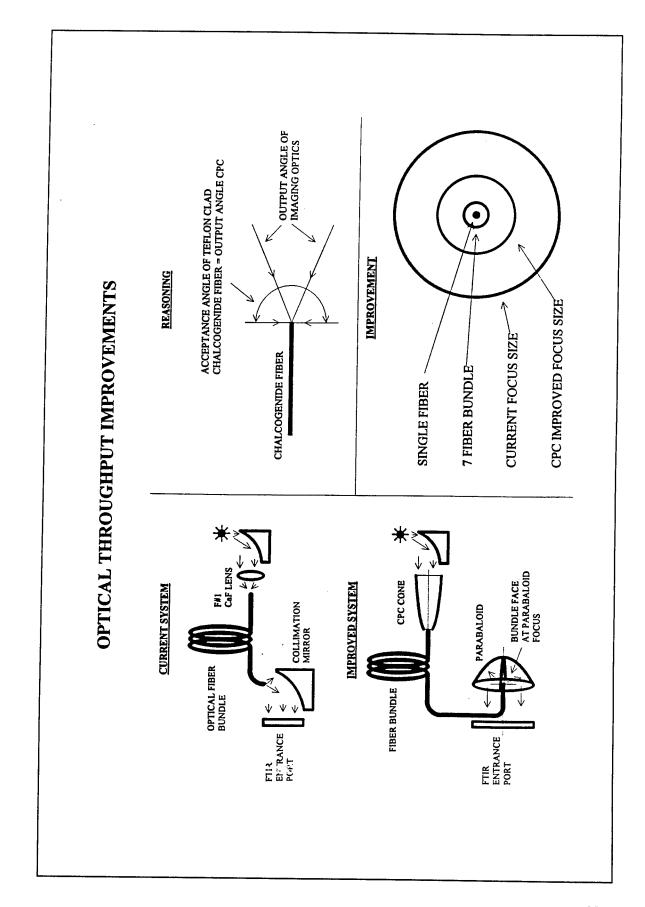
CPC OPERATION

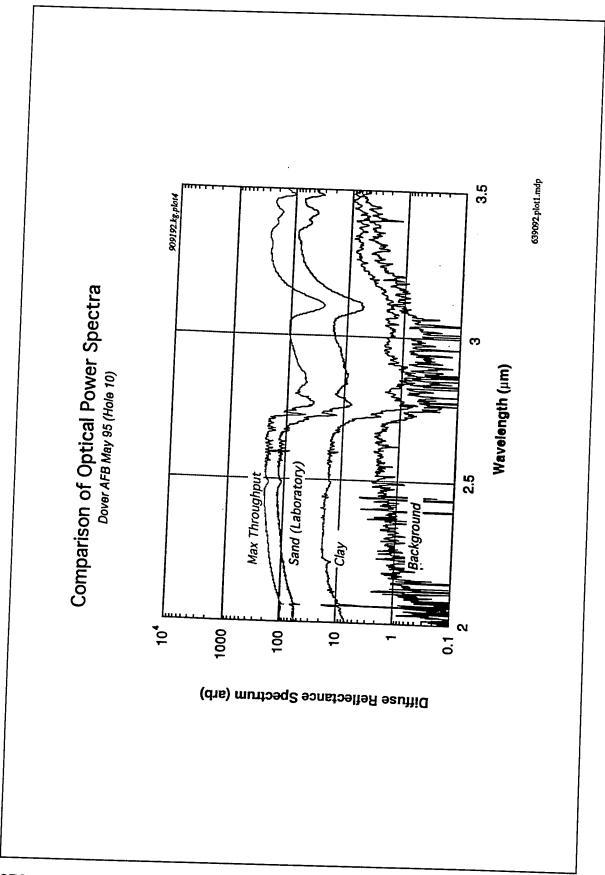
Fiber Bundle

NEW COLLECTION SYSTEM











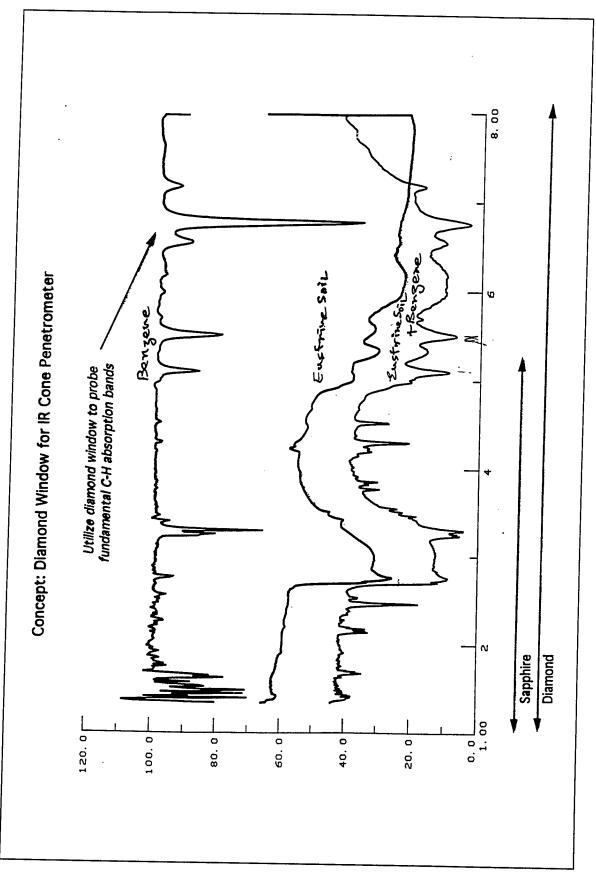
Wavelength (μm)

Wavelength (µm)

2

0.1

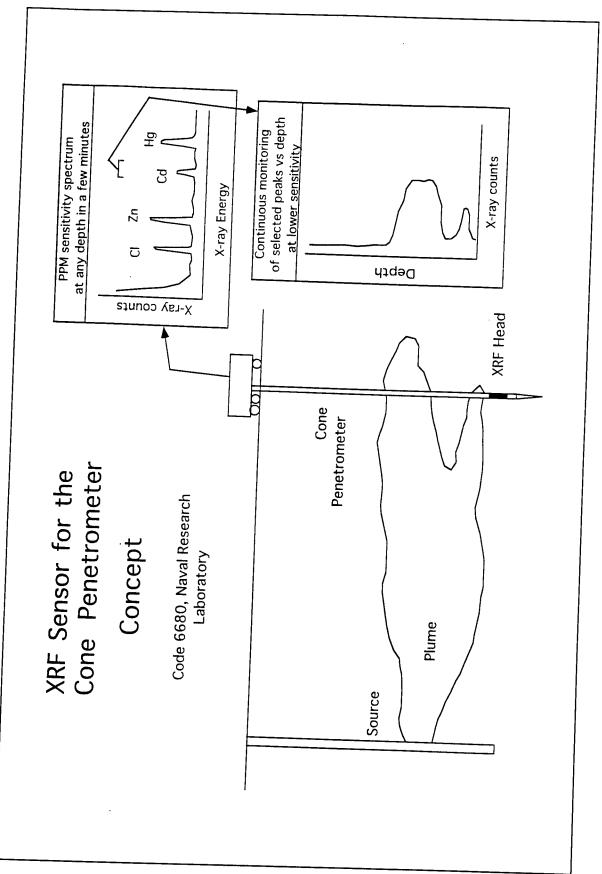
9



Metals Detection with an XRF Sensor for the Cone Penetrometer

W. T. Elam Naval Research Laboratory Code 6685 Washington, DC 20375-5345

30 August 1995



XRF Sensor for the Cone Penetrometer Requirements

must fit penetrometer geometry small diameter (max. 2 inch O. D.) rugged construction strong x-ray window

detect all metals Z>20 (scandium)

Detection limits well below 100 ppm (field screening)

100 or less second data collection times (approx. time required for penetrometer ram retraction)

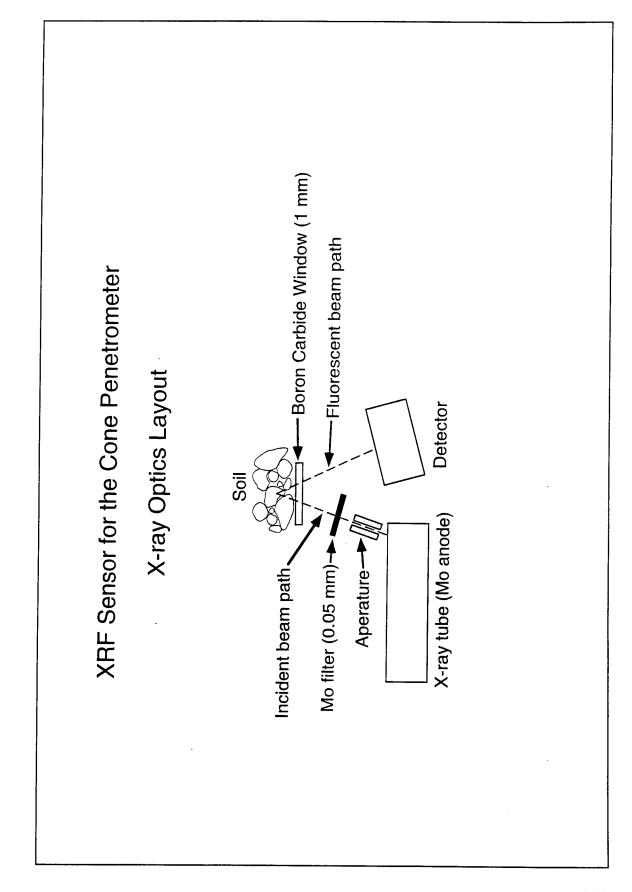
XRF Sensor for the Cone Penetrometer

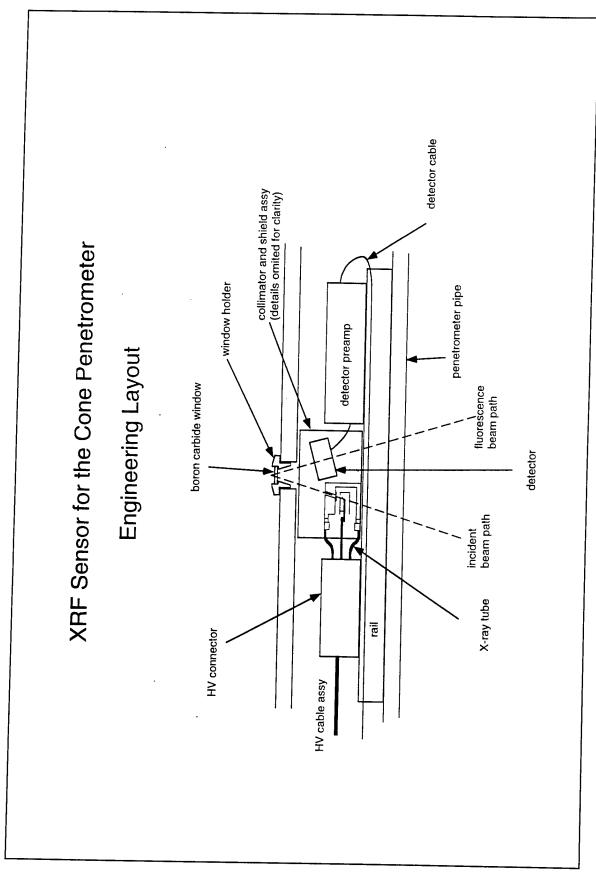
Sub-Systems

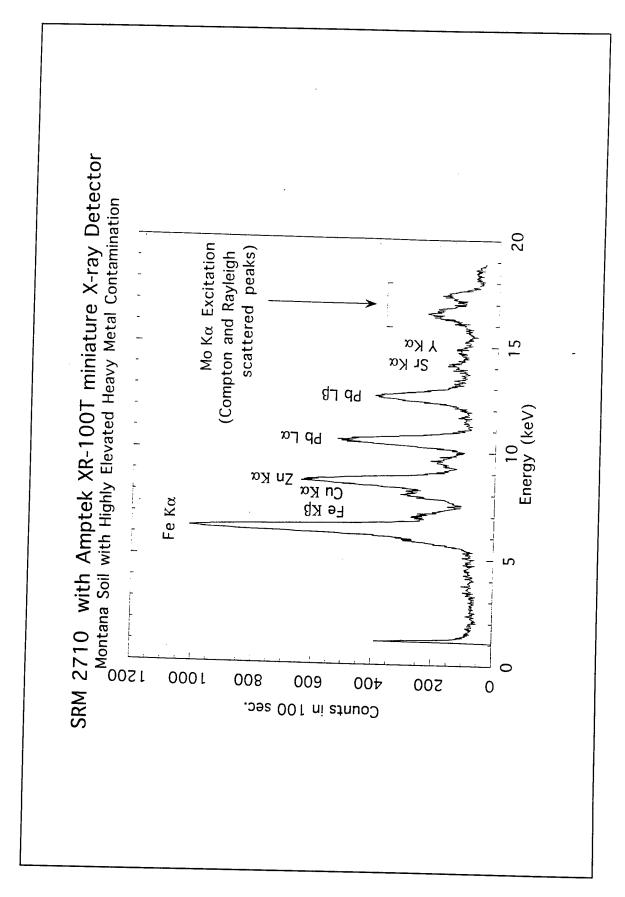
Below Ground	X-ray Source	Collimators	Window	X-ray Detector	Preamp	Mounting Platform	Heat Dissipation

High Voltage Signal Power Shields and Grounds Display Interface to Penetrometer Truck

282







XRF Sensor for the Cone Penetrometer

X-ray Tube Requirements

Critical requirements:

- Molybdenum anode
- Maximum operating voltage 35 kV (continuous)
 Maximum operating current 0.5 ma (continuous)
- Maximum operating power 18 watts (continuous)
 - Cooling via contact with housing
 - Maximum length 6 inches
- Focal spot approximately 0.080 inch (2 mm) diameter or less
- Maximum diameter 0.625 inches (15 mm) at any point on length

XRF Sensor for the Cone Penetrometer Prototype Development Timeline

Assemble Sensor

October 1995

March 1996

Obtain Performance Data (especially detection limits)

Summer 1996

Field Test of Sensor

287

XRF Sensor for the Cone Penetrometer

Requirements and Status

(as of August 1995)

Detector

On hand, tested

In progress

Boron Carbide Windows

Mounting rail X-ray tube

Re-mounted preamp

Received and mounted, testing in progress

On hand

Vendor selected, order in progress

Final design waiting on x-ray tube design

Collimators

Structural Components

Window holder

Pipe section

9 SERDP Peer Review Panel Conclusions and Recommendations

The peer review panel members raised questions and made comments throughout this workshop. The panel members were asked to submit their written comments to the workshop coordinator to be included in these proceedings. The following comments were submitted in memorandum form and have not been altered.

MEMORANDUM FOR THE RECORD

SUBJECT: Second Annual SCAPS Sensor Development Workshop

FROM: Jeff Marquesee

DATE: August 31, 1995

The annual Tri-Service SERDP SCAPS program review was held at Waterways Experiment Station August 29 and 30. The SCAPS Tri-Service funding profile from SERDP and other DoD sources is shown below.

	FY94 \$K	FY95 \$K	FY96 \$K	FY97 \$K
SERDP	3,375	1,060	1,790	2,350
Non-SERDP	2,641	2,580	850	350
Total	6,016	3,640	2,640	2,700

In addition to these funds, ESTCP and Navy DERA have provided funding for the demonstration and validation of SCAPS technology.

The SERDP Science Advisory Board requested that the program be reviewed by an independent peer review group every year. The review committee consisted of:

Dr. Jeffrey Marquesee, DoD

Mr. Eric Lightner, DOE

Dr. Greg Rosasco, NIST

Dr. Carl Enfield, EPA

The review covered the seven areas currently receiving SERDP funding. They are:

- 1. Laser Induced Breakdown Spectroscopy
- 2. Laser Induced Fluorescence Sensors: POL and Explosives
- 3. Fiber Optic Raman Sensors
- 4. Electrochemical Sensors: Explosives and VOCs
- 5. Spectral Gamma Probe
- 6. Sampling Technology
- 7. Data Processing Methodologies
- 8. Technology Demonstration

Details on these seven topics are available.

Attached are my comments and recommendations provided to the program manager regarding the ongoing SERDP funding work.

Comments on SERDP Funded SCAPS Development

General

- Overall, the work is important to the DoD and addresses real user needs. The quality is high and support should be maintained.
- For successful execution, tri-service participation is essential. Although the SCAPS program's level of tri-service cooperation is far beyond other environmental programs, improvements in coordination are still needed. In particular, the work being performed by the Air Force is not being coordinated sufficiently with the ongoing Army and Navy work.
- SCAPS clearly addresses a specific user defined requirement. The earlier development of the POL LIF sensor had close interaction with the user community. The current sensor development needs to maintain a high level of user interaction to assure that these sensors will provide operational capabilities needed by the DoD cleanup community. It is recommended that on a sensor/contaminant basis the developers meet with members of the user community and obtain appropriate feedback.

- The current review was limited to government participants. It is recommended that in the future the non-government groups involved in the SERDP funded R&D be invited.
- It is recommended that the program maintain its short term focus on providing the user community with near term technologies that can be used for screening the condition of a contaminated site. The current approach of simultaneously looking at multiple technical approaches to address a single problem should be maintained in order to move the technology to the field rapidly. While maintaining this near term focus, SERDP should also consider supplementary efforts to exploit the potentially more quantitative nature of these sensors. In the out years, the user community will have an increasing need for characterization tools that can monitor the progress of ongoing remediation activities. The value of a quantitative measurement of the ratio of various aromatic compounds by LIF would be high, even if the absolute scale for an individual compound cannot be determined.
- The role of field testing and demonstrations is important. The ongoing work under SERDP funding appears to be of mixed quality and at times unfocused. With increased support planned for these activities in FY96, it is important that the objectives of the various field tests be clearly defined.

Below are additional comments on the specific areas briefed.

Laser Induced Breakdown Spectroscopy

The work in this area has a great potential payoff and support should be maintained at a high level to assure a rapid transition to the field user.

Laser Induced Fluorescence Sensors

POL

- The ongoing work at NRaD is of high quality with an excellent short term focus on providing opportunities for technology insertion into existing systems.
- The lasers being provided by MIT/LL offer a great potential and should be fully exploited to determine their value.
- The work described by the Air Force and Navy appears uncoordinated and potentially duplicative. A coordinated program needs to be constructed.
- The Air Force work appears to be supporting one commercialized approach and overlaps the TRP funded work in this area.

Explosives

- There is great need for a sensor which could cost effectively and rapidly map out explosive contaminants in groundwater. This sensor is advertised as having that potential.
- The current effort appears to be funded at such a low level that it is below
 the critical mass needed to really advance the technology. The measurement approach needs to be pushed in the lab to answer the basic questions
 on feasibility followed by a decision to either drop support or significantly
 increase support.
- It is recommended that in the near term, lab experiments be performed to determine if this technology can detect explosives in the soil, then the focus must move to determine if there is a potential to differentiate between NO from explosives vs. NO from fertilizer sources that widely contaminant groundwater in the U.S. If there is no potential for differentiating these two sources then the user community in the Army needs to be queried on the potential value of such a sensor.

Fiber Optic Raman Sensors

- The Navy work briefed clearly showed the shortcomings of this approach. The work was high quality even if the resulting answer is a disappointment.
- The Navy is currently altering their work to look at surface enhanced Raman for a detector of DNAPL. Before proceeding with this project, it is recommended that the Navy assess whether such a technically sophisticated sensor is really the best approach if it will only be able to detect free product and if the market will support such a sensor.
- Given the recent results of the Navy, the current Air Force plans are not well justified. The work proposed is not clearly leading to an advancement, which will provide a new operational capability.

Electrochemical Sensors: Explosives and VOCs

• These sensors represent good near term products that should be transitioned to the user rapidly.

Spectral Gamma Probe

• This work does not address a DoD requirement. It is recommended that SERDP support for this work be discontinued.

Sampling Technology

- The thermal desorption sampling is an excellent tool that should be transitioned rapidly. The future SERDP work should focus on questions associated with its operational use; i.e., developing an appropriate protocol for field use to assure an accurate sample is collected.
- The multi-port sampler results were inconsistent. The modeling proposed to understand the results will not fully address the important questions. It is recommended that additional experimental work be performed to identify the cause of the anomalous results.

Data Processing Methodologies

• It is recommended that this effort be decreased in the out years. The work presented appeared to be of good quality, but SCAPS should exploit and rely on existing commercial software to the maximum extent possible.

Technology Demonstration

- The planned demonstrations conducted by the Services require greater coordination.
- The value and expended product for each field test should be explicitly defined prior to initiating any extensive field activities.

SCAPS Technical Peer Review -- August 29-30, 1995 Report of Greg Rosasco, NIST

General comment:

As discussed at the time of the meeting, it would be most helpful for the purposes of such a review to provide an overall roadmap which provides the rationale for the technical program for each of the technologies presently encompassed by the SERDP sensor acceleration funding. This roadmap would provide a brief description of the measurement problem, e.g., POL contamination characterization, the critical requirements of the measurement system, e.g., detection and relative quantitation at the sub 400 ppm level in the vadose or water table level for the following compounds in an asserted priority order. The problem definition should give some sense of user priority and critical measurement needs, both within an area, e.g., energetic compound detection, and between areas, e.g., relative importance of heavy metal detection vs. POLs or explosives. The problem definition would be followed by a brief assessment of the current state-of-the-art in sensor technology to address this problem, this should logically set the rationale for the SERDP funded effort. Within each technology selected for acceleration, critical decision points, accomplishment and time schedules, should be identified to understand the decisions as to continuation, expansion, cessation, incorporation in penetrometer test, etc. The comments with regard to "not understanding how the AF portion of the effort fit into the overall strategy" I think were engendered by this lack of clear understanding of the bigger picture. This not to say that such a roadmap or plan doesn't exit, but rather that the review team could not discern the plan in the time allowed for the review.

Individual program areas:

LIBS: An innovative, highly promising approach which, if rapidly incorporated in survey studies, could greatly add to the understanding of heavy metal contamination, transport, and remediation. Since the fiber optic transmission of the receiver is better than 20 percent for wavelengths above 330 nm, some evaluation of the ability to detect Cd and Zn for longer wavelengths should be tested in the lab. The likelihood that the AOTF-PMT down-hole detector approach will provide analytically significant data (in the 220 nm region or any other spectral region) in time to incorporate the technology into the SCAPS system does not appear to be high. The inherent irreproducibility of the spectrum on a shot-to-shot basis suggests that the only useful normalization will come from simultaneous multielement comparisons available from the currently practiced multichannel spectroscopy approach. The downhole, high energy Nd:YAG system seems ideal (even if the rep rate is low). Some focus adjustment may be required to optimize plasma generation depending on soil type; as an alternative to the current design for the probe, one could imagine a small, 250 micrometer port which would allow access to the soil with a purge and dump area below it to allow any material that entered through the port to be expelled. The system seems very close to ready for field tests. Good work.

LIF for POL: Outstanding results, especially those related by Dr. Lieberman in his review of the Navy demonstrations in CA. The potentialities of the diode laser pumped downhole Nd:YAG laser are outstanding. If the system could be configured to allow wavelength selection, the range of excitation wavelengths would be remarkable, and thereby allow a tremendous number of tests, including wavelength optimization for Raman spectroscopy, which is after all, at least operationally, just off resonance fluorescence. The wavelength selection could include 808 nm from the diode, 1060 nm from the YAG, either of which might reduce fluorescence for Raman, (unfortunately one would have to use FT Raman analysis for the 1060 excitation). The 532 nm power would be useful for Raman excitation and would eliminate the current problems with the interfering silica Raman spectrum coming from the input excitation fiber in the current FORS system, this may allow mineral characterization and perhaps water content measurements, a subject of interest in general. The ability to switch to short wavelength excitation of the POLs may add the ability to do some relative quantitation of heavy and light fractions or aging, as discussed in the meeting. This is a first rate opportunity and should be pushed hard. No similar justification has been advanced for the dye system, the OPO, the powdered doubler or the Ti:Sapphire work. The explosives detection effort of Sausa should be funded at a sufficient level to allow a critical test of the possibilities of detection of the compounds of interest in the matrix of interest in the presence of the user identified interferants. No spectroscopy, simply see if a one photon, deep UV or a two photon, excitation detection scheme will give qualitative, analytically useful (perhaps for screening purposes) indication of the presence of the explosives.

FORS: The work to date is first rate, a sensible, "utilize the state-of-the-art approach" has been followed. Other than the suggestions above with regard to the potential of a downhole multiwavelength source, the near term utility of this system seems to have been evaluated. It is unfortunate that no data appear to have been taken in any part of the push, prior to failure in the one field test that was reported. There is still the question as to the utility of Raman spectroscopy to help distinguish the nature of the geological layer that the probe is passing through, as a supplement to the other, admittedly crude, characterizations available from the geotechnical stress/friction data. Although I am vaguely familiar with a SERS based enhancement of sensitivity for Raman spectroscopy, I think there are other extractive, trapping technologies available and better suited to the needs of SCAPS.

Electrochemical sensors: Ready for incorporation in the SCAPS system and should be subjected to complete validation tests in parallel with other such tests. Good work.

Spectral gamma: Subcritical effort, no further comment.

Sampling technology: This catalytically enhanced thermal desorption technique appears ready for field validation and deployment. Good work. The multiport sampler needs some more thought as to how to perform the validation studies, but it appears otherwise a mature technology for soil gas

sampling. I am not sure why one needs both the thermal desorption and the multiport to get soil gas, one could just turn off the heater in the retracted cone version of the thermal desorption sampler and have a means to sample a controlled volume for soil gas. This multiport sampler is mature, it does not need more SERDP acceleration funding.

Data processing methodologies: Should be incorporated as required in the transitioning of each technology into the SCAPS. It should not be a research area in itself.

Field Demonstrations: Some are just field tests, and these should be differentiated and included in the process of transitioning the technology into the SCAPS. The demonstrations at Dover and those conducted at Port Hueneme and North Island jointly with CAL EPA and the Western Governors Association were outstanding examples of what to do in a field demonstration. More sensors and more data should be obtained in such tests, since so much expense goes into the testing and supportive extractive analyses.

Greg Rosasco
National Institute of Standards and Technology
Process Measurements Division
Physics Bldg. *B312
Gaithersburg, MD 20899
Phone (301) 975 2609
FAX (301) 869 5924

References

- Cespedes, E. R., Miles, B. H., and Lieberman, S. H. (1994). "Development of optical sensors for the Site Characterization and Analysis Penetrometer System (SCAPS)." Proceedings of the International Specialty Conference on Optical Sensing for Environmental Monitoring Vol. SP89, Air and Waste Management Association/SPIE, Atlanta, GA, 621-632.
- Lieberman, S. H., Theriault, G. A., Cooper, S. S., Malone, P. G., Olsen, R. S., and Lurk, P. W. (1991). "Rapid subsurface in situ screening of petroleum hydrocarbon contamination using laser induced fluorescence over optical fibers." Proceedings of the Second International Symposium on Filed Screening Methods for Hazardous Wastes and Toxic Chemicals, Air and Waste Management Association, Las Vegas, NV, 57-63.
- SERDP. (1995). "1995 Annual Report and Five-Year (1995-1999) Strategic Investment Plan," Arlington, VA, CU-4 CU-9.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden. To Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Sudget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE		3. REPORT TYPE AND DATES COVERED	
	August 1996	Final report	5. FUNDING NUMBERS	
4. TITLE AND SUBTITLE Proceedings of the 2nd Annual Penetrometer System (SCAPS) 29-30 August 1995, Vicksburg, 5. AUTHOR(S)	5. FUNDING NUMBERS			
Ernesto R. Cespedes, Diane M				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)			8. PERFORMING ORGANIZATION REPORT NUMBER	
U.S. Army Engineer Waterway 3909 Halls Ferry Road Vicksburg, MS 39180-6199	s Experiment Station		Miscellaneous Paper SERDP-96-2	
9. SPONSORING/MONITORING AGENC	Y NAME(S) AND ADDRESS(ES)	10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
U.S. Army Corps of Engineers Washington, DC 20314-1000			AGENCI REFORM NOMBER	
11. SUPPLEMENTARY NOTES				
Available from National Techn	ical Information Service	, 5285 Port Royal Ro	oad, Springfield, VA 22161.	
12a. DISTRIBUTION/AVAILABILITY STA	TEMENT		12b. DISTRIBUTION CODE	
Approved for public release; di	istribution is unlimited.		·	
13. ABSTRACT (Maximum 200 words)				

The Second Annual Site Characterization and Analysis Penetrometer System (SCAPS) Sensor Development Workshop was held at the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, during August 29 and 30, 1996. In attendance were researchers, managers, and SCAPS users representing the Army, Navy, Air Force, the Department of Defense, the Department of Energy, the Environmental Protection Agency, and the National Institute of Standards and Technology. Workshop participants presented briefings on the status of their SCAPS-related sensor research, development, and demonstration efforts. Managers and users of SCAPS technologies participated in the briefings and discussions and described the needs and concerns from the users' perspective. The Peer Review Panel evaluated the progress of the Tri-Service SCAPS sensor development project and presented recommendations for future work.

14.	SUBJECT TERMS Chemical sensors	In situ sensors		15. NUMBER OF PAGES 299
	Cone penetrometer	Monitoring		16. PRICE CODE
	Environmental sensors	Site characterization		
17.	SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
	UNCLASSIFIED	UNCLASSIFIED		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18 298-102